UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 676

Contribution from the Forest Service
HENRY S. GRAVES, Forester

FOREST PRODUCTS LABORATORY, Madison, Wisconsin
In Cooperation with the University of Wisconsin

Washington, D. C. PROFESSIONAL PAPER July 16, 1919

THE RELATION OF THE SHRINKAGE AND STRENGTH PROPERTIES OF WOOD TO ITS SPECIFIC GRAVITY

By

J. A. NEWLIN, in Charge, Section of Timber Mechanics, and T. R. C. WILSON, Engineer in Forest Products

CONTENTS

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CONTENTS.

PURPOSE.

It has long been recognized that there are direct relations between the specific gravity, or density, of a wood and its strength properties.[1] By the analysis of over 200,000 tests, the Forest Products Laboratory, conducted in cooperation with the University of Wisconsin, Madison, Wis., has now definitely established these relations. It is the purpose of this bulletin to state these relations and to put the expression of them in such form as to render them easily useful (1) for estimating the properties of any particular timber; (2) for selecting timber for any given purpose; (3) for comparing the various species; and (4) for determining in what way the species are exceptional and to what uses they are best adapted.

It has usually been assumed that the strength of wood varies directly with the first power of its density; i.e., that the respective strengths of two sticks would differ in the same proportion as the densities. It was recognized that fiber stress at elastic limit in compression perpendicular to the grain, or bearing strength on side

[1] Accurate determinations made at the Forest Products Laboratory on seven species of wood, including both hardwood and coniferous species, showed a range of only about 4½ per cent in the density of the wood substance, or material of which the cell walls are composed. Since the density of wood substance is so nearly constant, it may be said that the density or specific gravity of a given piece of wood is a measure of the amount of wood substance contained in it.

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surface, and work values in static bending or toughness, deviate very erratically from this relation; but the relation was supposed to hold especially true in the case of such properties as modulus of rupture, or maximum bending strength, and strength in compression parallel

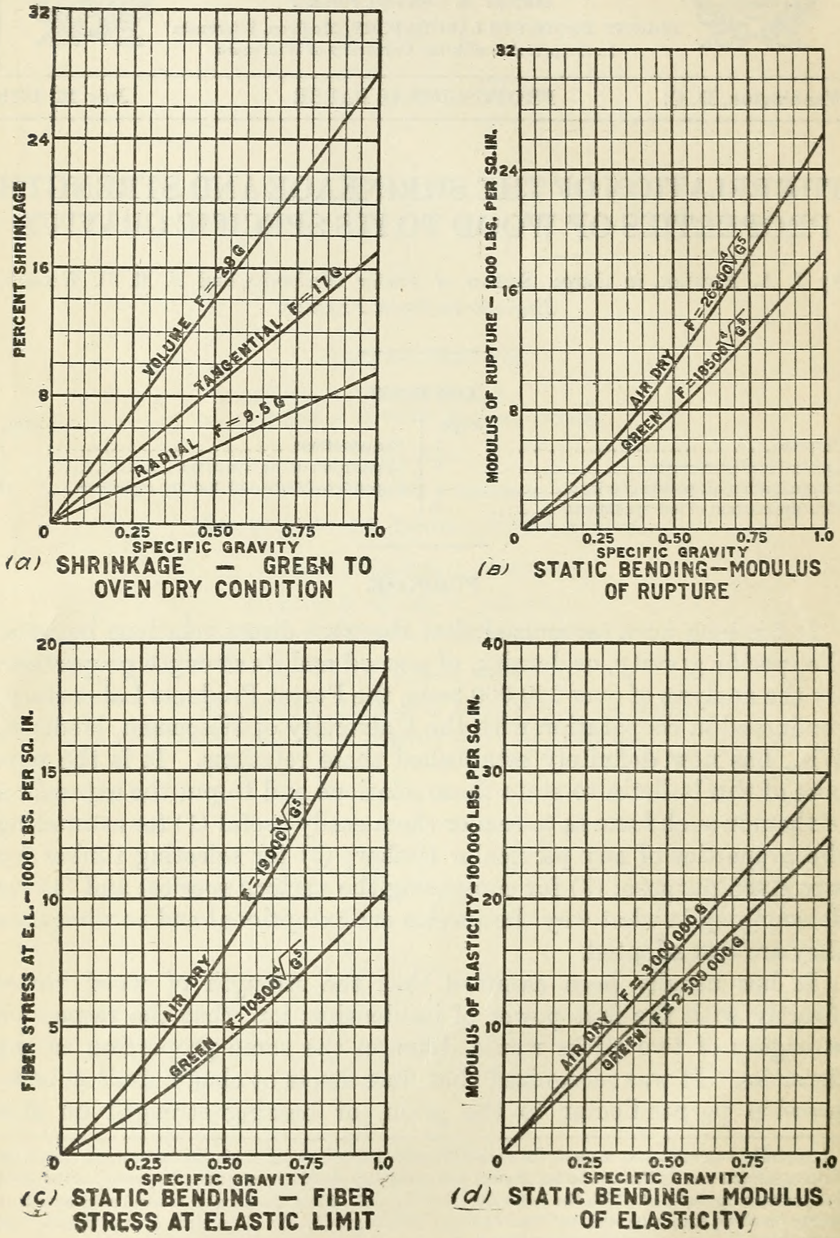


Fig. 1.

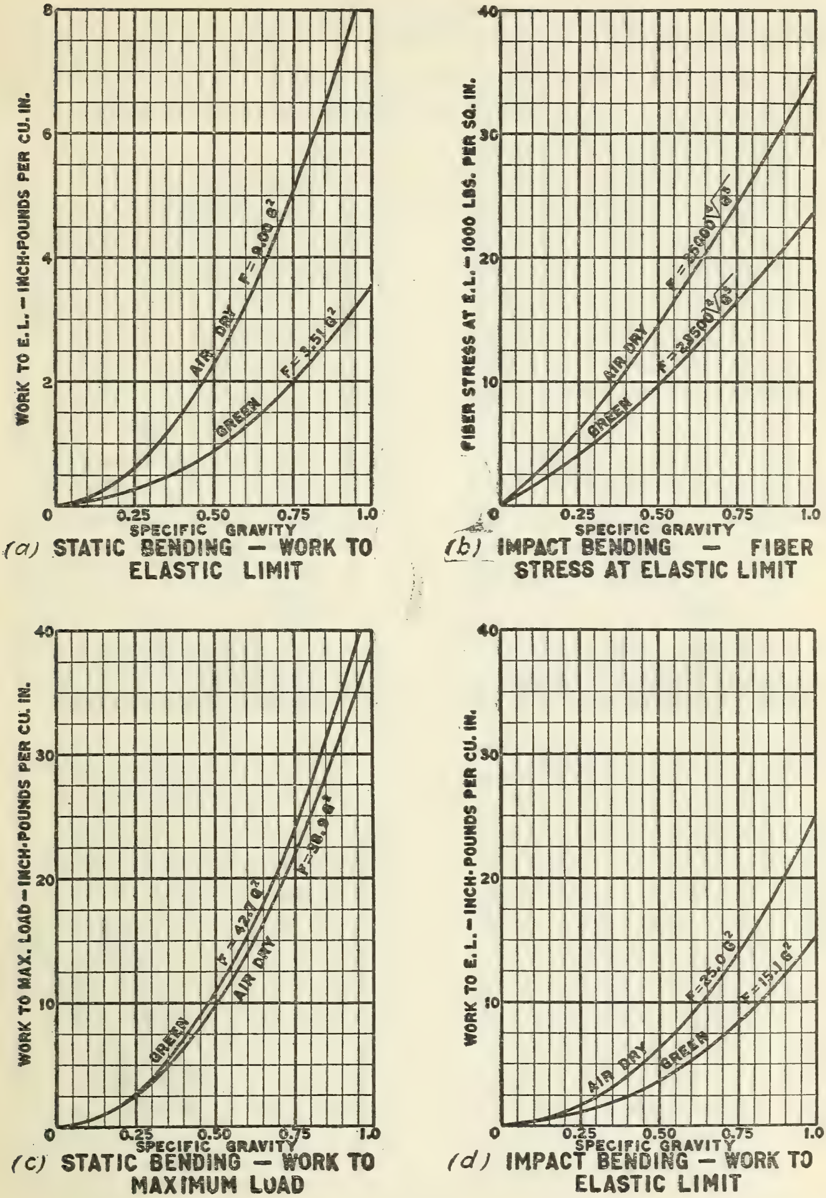


Fig. 2.

to the grain, or strength as a column. It has also been supposed that the relation applied between pieces of the same species, between pieces of different species, and between average results of strength tests on different species. A study of the data at present available, which are derived from a much larger number of tests and which cover a greater

range in specific gravity and strength values than was true of the data available heretofore, made it evident that these assumptions were inaccurate and that there was a better and more correct method expressing the actual relations between specific gravity and strength.

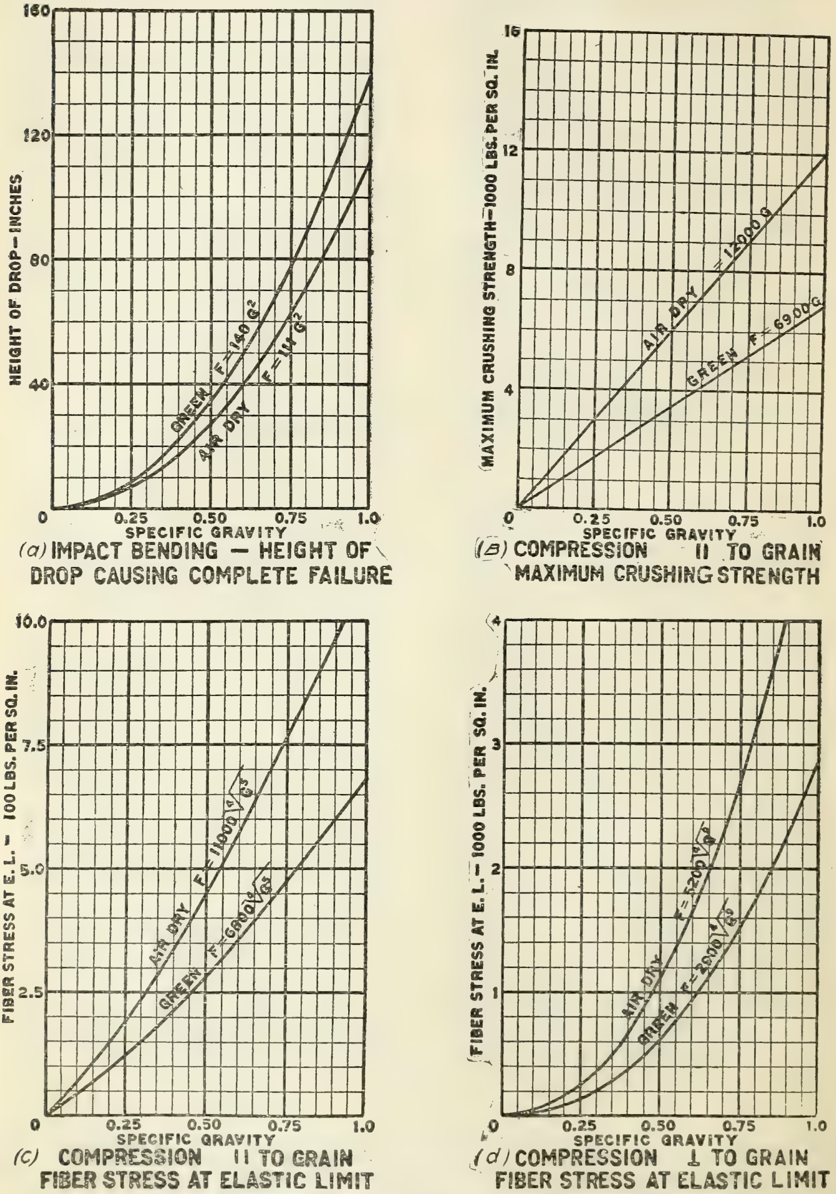


FIG. 3.

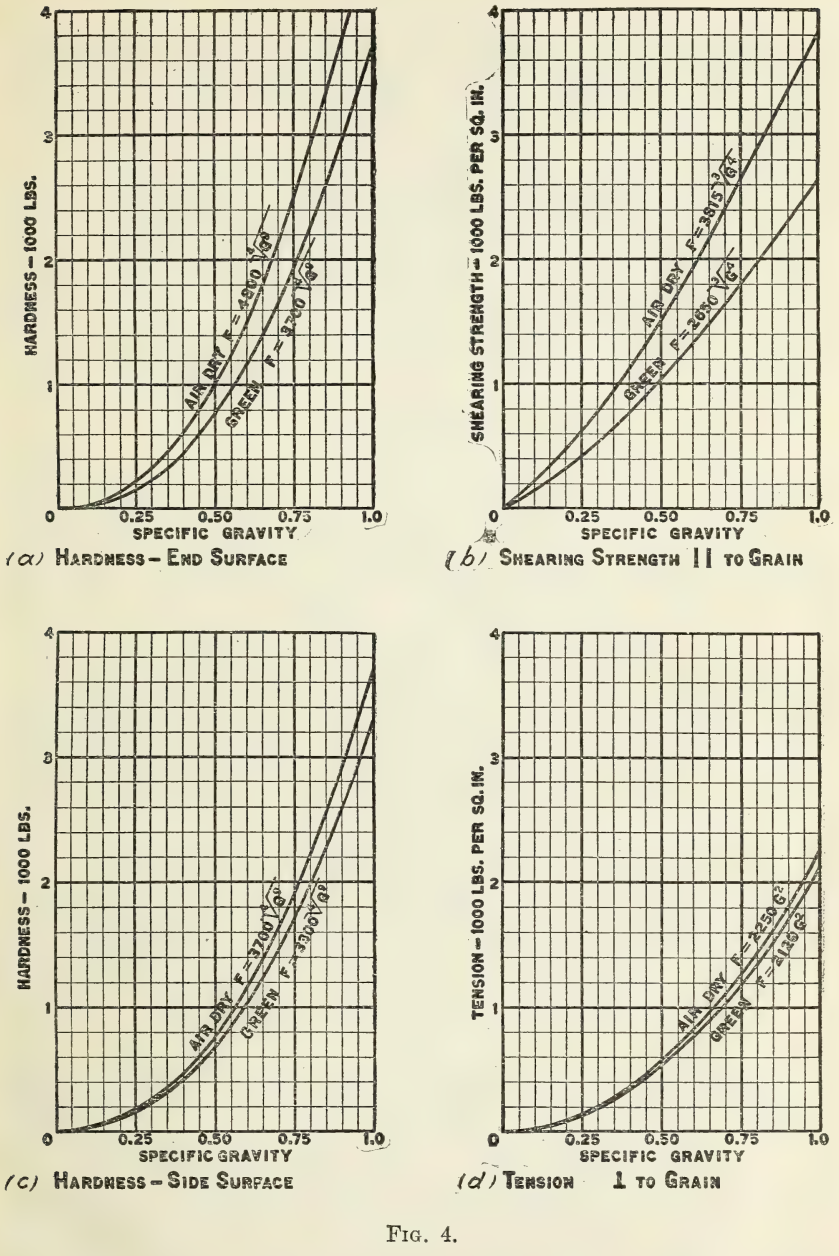


FIG. 4.

In order that the relation between specific gravity and each of the various mechanical properties of wood may be easily put to practical use, the relation, both for green and for air-dry material, is given in the form of an equation (Table 1) and, in addition, in the form of a curve (figs. 1 to 4).

SPECIES-LOCALITY AVERAGES.

The specific-gravity relations given in this bulletin are derived from a study of what may be called "species-locality" averages; that is, each average represents tests of material of one species from one locality.

There are two principal reasons for using "species-locality" averages in preference to the results of individual tests. First, the number of individual tests is quite large, amounting in some instances to as many as 900 from a single "species-locality", so that an immense amount of work is saved by the use of the "species-locality" averages; second, if individual tests were used, the "species-localities" having larger trees or a larger number of trees would include a larger number of tests and would have undue weight in determining the relations.

The method of analysis used is applicable also to individual tests from a single species to determine the specific gravity relations within that species. It has been applied to a few of the properties of some of the more important species which are used for structural timbers where there was a rather large number of test pieces and a considerable range in specific gravity.

DETERMINATION OF SPECIFIC GRAVITY.

Specific gravity of wood, as used herein, is based on the volume of the specimens when tested (green or air-dry) and their weight when in an oven-dry condition; that is, it is the ratio of the weight of the specimen of wood, *oven-dry*, to the weight of a volume of water equal to the *volume of the specimen at the time of test*. Because of the shrinkage which takes place in wood when it is dried, this figure is not the true specific gravity of a piece of oven-dry wood. The method, however, is easily applied to each specimen tested, and is the standard method of the Forest Service for the determination of a specific-gravity figure for use in studying the properties of wood.

MOISTURE CONTENT OF TEST SPECIMENS.

Both green and air-dry specimens were used in the tests, and the relations between specific gravity and strength were determined separately for green and air-dry wood. Variations in the moisture content of wood have no effect on its mechanical properties so long as the wood is thoroughly green; they have considerable influence on these properties, however, as soon as the wood becomes air-dry, or partially air-dry. Accurate comparisons can not be made between the properties of two lots of air-dry specimens unless they were tested at the same moisture content or adjustments made in the strength figures for difference in moisture content.

The moisture content of the air-dry material at the time of test varied from 8 to 18 per cent. Modulus of rupture and maximum strength in compression parallel to the grain were adjusted to a moisture content of 12 per cent before determinations of the relation of these properties to the specific gravity was made. This adjustment was possible because the laws governing the variation of these properties with varying moisture content are fairly well established. However, in the case of the other strength functions their variation with varying moisture content has not been studied in detail and no such adjustment is possible with any very great degree of accuracy. Consequently, the actual moisture content values as obtained from tests have been used in the determination of the relation of these properties to specific gravity.

THE EQUATIONS.

Table 1 and figures 1 to 4 give equations which represent the average relations between specific gravity and each of the mechanical properties. All the "species-locality" averages available on any particular property were considered in deriving the equations for that property. The number of "species-locality" averages from which an equation is derived varies from 84 to 178. This variation is due to the fact that several of the tests were not used in some of the earlier testing work and to the fact that tests have not yet been completed on air-dry material for all of the "species-localities" listed.

Table 1 gives first the equations for shrinkage and for each of the strength properties of green and air-dry wood in terms of the specific gravity. These equations, as explained in the appendix, are reduced to a simple form; and the powers of gravity used are such that the equations may be solved by arithmetical operations and without the use of higher mathematics. However, to simplify even further the use of the equations, figures 1 to 4 have been prepared for their solution. Each of the curves shown in these diagrams represents the equation connecting specific gravity and one of the properties of wood. The curves representing the equations for radial, tangential, and volumetric shrinkage appear in figure 1(a). In each of the other figures, 1(b) to 4(d), appear two curves for some one mechanical property. One of these curves is for green and the other for air-dry material. If the specific gravity is known, the equation value for any one or all of the properties of the wood in question may be readily determined from the curves without computation.

The second portion of Table 1 gives what may be termed a measure of the accuracy of the respective equations. It is not to be expected that all the "species-locality" averages will satisfy the equation exactly or even very closely. Some of the properties are more erratic than others, so that one "species-locality" may far exceed

the equation values and another "species-locality" fall far below them.

In figure 5 are plotted the curves of the equation for modulus of rupture in static bending in green material, $M=18500\sqrt[4]{g^5}$, and of the equation for the same property in air-dry material, $M=26200\sqrt[4]{g^5}$. In order to give a graphical idea as to the reliability of these equations, the specific gravity and the modulus of rupture of each "species-locality" have been plotted as a point. The reference number placed near each plotted point is assigned to the "species-locality" in the order of its respective specfic gravity as determined from compression parallel to grain specimens of green wood. In figures 6, 7, and 8 the data are given for the curves on shrinkage in volume from green to oven-dry condition, maximum crushing strength in compression parallel to grain, and fiber strength at elastic limit in compression perpendicular to grain.

Under each property is listed in this second portion of Table 1, for both green and air-dry conditions, those percentages of the equation value above which were one-tenth of the "species-localities." Similarly, there are listed those percentages above which were one-fourth of the "species-localities," those below which were one-fourth, and those below which were one-tenth. For instance, in static bending (green), one-tenth of the "species-localities" tested had a modulus of rupture of more than 114 per cent of what the specific gravity equation indicated they should have had; one-fourth of them had a modulus of rupture greater than 108 per cent of the equation value; one-fourth of them less than 91 per cent of the equation value; and the lowest one-tenth had a modulus of rupture less than 84 per cent of what the equation indicated they should have had. It follows from these figures that one-half of the "species-localities" had a modulus of rupture of between 91 per cent and 108 per cent of the value given by the equation, and that the other one-half were evenly divided between those that were more than 108 per cent and those that were less than 91 per cent.

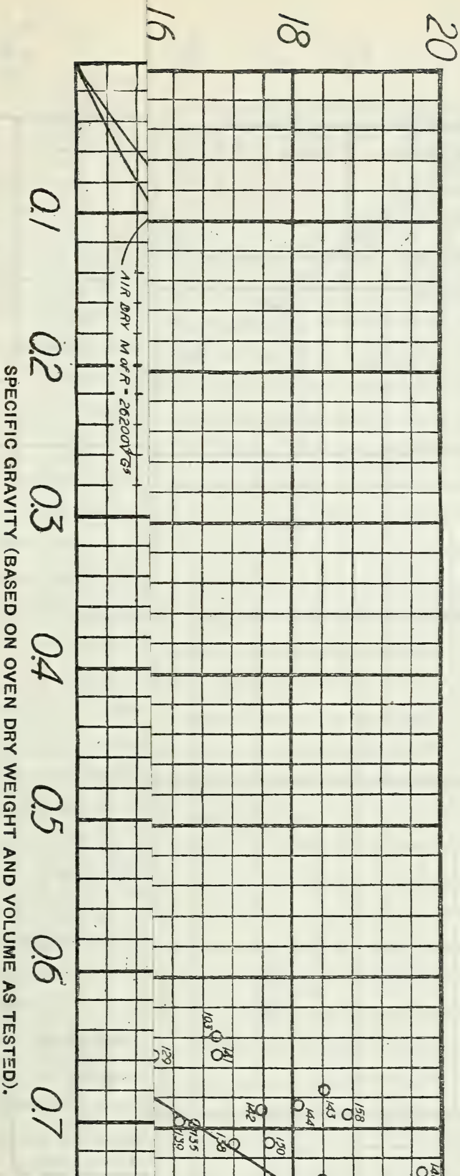
The third portion of Table 1 gives the actual value of each property for each "species-locality" as determined by the tests, expressed as a percentage of the value computed from the specific gravity by the use of the equation at the head of the column. For instance, it is found from the table that air-dry Biltmore ash has a modulus of rupture 98 per cent as great as that of the average wood of its specific gravity, the modulus of rupture of the average wood of this specific gravity being the figure given by the equation. These percentages are given for both green and air-dry wood.

Big shellbark	Mississippi	135	Sumac, staghorn	Wisconsin	61
Do	Ohio	154	Sycamore	Indiana	63
Bitternut	...do	139	Do	Tennessee	65
Mockernut	Mississippi	144	Umbrella, Fraser	...do	45
Do	Pennsylvania	159	Willow:		
Do	West Virginia	155	Black	Wisconsin	11
Nutmeg	Mississippi	112	Western black	Oregon	43a
Pignut	...do	148	Witch hazel	Tennessee	114
Do	Ohio	157			
Do	Pennsylvania	160			
Do	West Virginia	161			

CONIFERS.

Cedar:			Pine—Continued.		
Incense	California	26	Lodgepole	Montana, Granite County.	41a
Western red	Montana	2	Do	Montana, Jefferson County.	40a
Do	Washington	10	Do	Wyoming	34
White	Wisconsin	1	Longleaf	Florida	123
Cypress, bald	Louisiana	62	Do	Louisiana, Lake Charles.	113
Douglas fir	California	45a	Do	Louisiana, Tangipahoa Parish.	96
Do	Oregon	67a	Do	Mississippi	95
Do	Washington, Chehalis County.	46a	Norway	Wisconsin	57
Do	Washington, Lewis County.	75	Pitch	Tennessee	71
Do	Washington and Oregon.	67	Pond	Florida	86
Do	Wyoming	48	Shortleaf	Arkansas	77
Fir:			Sugar	California	22
Alpine	Colorado	4	Table Mountain	Tennessee	82
Amabilis	Oregon	39	Western white	Montana	42
Do	Washington	18	Western yellow	Arizona	19
Balsam	Wisconsin	14	Western	California	37
Grand	Montana	36	Do	Colorado	41
Noble	Oregon	16	Do	Montana	32
White	California	17	White	Wisconsin	25
Hemlock:			Redwood	California, Albion	28
Black	Montana	47	Do	California, Korbel	13
Eastern	Tennessee	52	Spruce:		
Do	Wisconsin	15	Engelmann	Colorado, Grand County.	8
Western	Washington	50	Do	Colorado, San Miguel County.	3
Larch, western	Montana	84	Red	New Hampshire	44
Do	Washington	64	Do	Tennessee	29
Pine:			White	New Hampshire	7
Cuban	Florida	127	Do	Wisconsin	38
Jack	Wisconsin	43	Tamarack	...do	81
Jeffrey	California	33	Yew, western	Washington	134
Loblolly	Florida	88			
Lodgepole	Colorado	31			
Do	Montana, Gallatin County.	35a			

65977°—19 (To precede page 9. Faces Fig. 5.) No. 1.



16
18
20
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
AIR DRY M of R = 26200 $\sqrt{G^5}$
SPECIFIC GRAVITY (BASED ON OVEN DRY WEIGHT AND VOLUME AS TESTED).

LIST OF SPECIES AND REFERENCE NUMBERS FOR FIGURES 5 TO 9.

HARDWOODS.

Species.	Locality.	Reference No.
Alder, red	Washington	30
Ash:		
Biltmore	Tennessee	91
Black	Michigan	60
Do	Wisconsin	70
Blue	Kentucky	99
Green	Louisiana	93
Do	Missouri	100
Pumpkin	do	79
White	Arkansas	106
Do	New York	128
Do	West Virginia	83
Aspen	Wisconsin	23
Largetooth	do	20
Basswood	Pennsylvania	12
Do	Wisconsin	5
Beech	Indiana	110
Do	Pennsylvania	98
Birch:		
Paper	Wisconsin	73
Sweet	Pennsylvania	129
Yellow	do	107
Do	Wisconsin	103
Buckeye, yellow	Tennessee	9
Buckthorn, cascara	Oregon	84a
Butternut	Tennessee	27
Do	Wisconsin	21
Chinquapin, western	Oregon	46b
Cherry:		
Black	Pennsylvania	72
Wild red	Tennessee	24
Chestnut	Maryland	46
Do	Tennessee	40
Cottonwood, black	Washington	6
Cucumber tree	Tennessee	59
Dogwood:		
Flowering	do	151
Western	Oregon	125a
Elder, pale	do	69a
Elm:		
Cork	Wisconsin, Marathon County.	126
Do	Wisconsin, Rusk County.	120
Slippery	Indiana	102
Do	Wisconsin	74
White	Pennsylvania	55
Do	Wisconsin	53
Greenheart		165
Gum:		
Black	Tennessee	68
Blue (Eucalyptus).	California	147
Cotton	Louisiana	76
Red	Missouri	54
Hackberry	Indiana	90
Do	Wisconsin	78
Haw, pear	do	146
Hickory:		
Big shellbark	Mississippi	135
Do	Ohio	154
Bitternut	do	139
Mockernut	Mississippi	144
Do	Pennsylvania	159
Do	West Virginia	155
Nutmeg	Mississippi	112
Pignut	do	148
Do	Ohio	157
Do	Pennsylvania	160
Do	West Virginia	161
Hickory—Continued.		
Shagbark	Mississippi	140
Do	Ohio	152
Do	Pennsylvania	143
Do	West Virginia	153
Water	Mississippi	141
Holly, American	Tennessee	87
Hornbeam	do	149
Laurel, mountain	do	145
Locust:		
Black	do	158
Honey	Indiana	162
Madrona	California	101
Do	Oregon	128a
Magnolia	Louisiana	66
Maple:		
Oregon	Washington	58
Red	Pennsylvania	69
Do	Wisconsin	92
Silver	do	56
Sugar	Indiana	104
Do	Pennsylvania	108
Do	Wisconsin	124
Oak:		
Bur	do	125
California black	California	80
Canyon live	do	163
Chestnut	Tennessee	121
Cow	Louisiana	133
Laurel	do	116
Post	Arkansas	130
Do	Louisiana	137
Red	Arkansas	119
Do	Indiana	118
Do	Louisiana	117
Do	Tennessee	97
Highland Spanish.	Louisiana	94
Lowland Spanish	do	142
Swamp white	Indiana	150
Tanbark	California	115
Water	Louisiana	111
White	Arkansas	132
Do	Indiana	138
Do	Louisiana, Richland Parish.	136
Do	Louisiana, Winn Parish.	131
Willow	Louisiana	109
Yellow	Arkansas	122
Do	Wisconsin	105
Osage orange	Indiana	164
Poplar, yellow (tulip tree).	Tennessee	35
Rhododendron, great	do	85
Sassafras	do	51
Serviceberry	do	156
Silverbell tree	do	49
Sourwood	do	89
Sumac, staghorn	Wisconsin	61
Sycamore	Indiana	63
Do	Tennessee	65
Umbrella, Fraser	do	45
Willow:		
Black	Wisconsin	11
Western black	Oregon	43a
Witch hazel	Tennessee	114

CONIFERS.

Species.	Locality.	Reference No.
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Do	Washington	10
White	Wisconsin	1
Cypress, bald	Louisiana	62
Douglas fir	California	45a
Do	Oregon	67a
Do	Washington, Chehalis County.	46a
Do	Washington, Lewis County.	75
Do	Washington and Oregon.	67
Do	Wyoming	48
Fir:		
Alpine	Colorado	4
Amabilis	Oregon	39
Do	Washington	18
Balsam	Wisconsin	14
Grand	Montana	36
Noble	Oregon	16
White	California	17
Hemlock:		
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Eastern	Tennessee	52
Do	Wisconsin	15
Western	Washington	50
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Do	Washington	64
Pine:		
Cuban	Florida	127
Jack	Wisconsin	43
Jeffrey	California	33
Loblolly	Florida	88
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Longleaf	Florida	123
Do	Louisiana, Lake Charles.	113
Do	Louisiana, Tangipahoa Parish.	96
Do	Mississippi	95
Norway	Wisconsin	57
Pitch	Tennessee	71
Pond	Florida	86
Shortleaf	Arkansas	77
Sugar	California	22
Table Mountain	Tennessee	82
Western white	Montana	42
Western yellow	Arizona	19
Western	California	37
Do	Colorado	41
Do	Montana	32
White	Wisconsin	25
Redwood	California, Albion	28
Do	California, Korbel	13
Spruce:		
Engelmann	Colorado, Grand County.	8
Do	Colorado, San Miguel County.	3
Red	New Hampshire	44
Do	Tennessee	29
White	New Hampshire	7
Do	Wisconsin	38
Tamarack	do	81
Yew, western	Washington	134

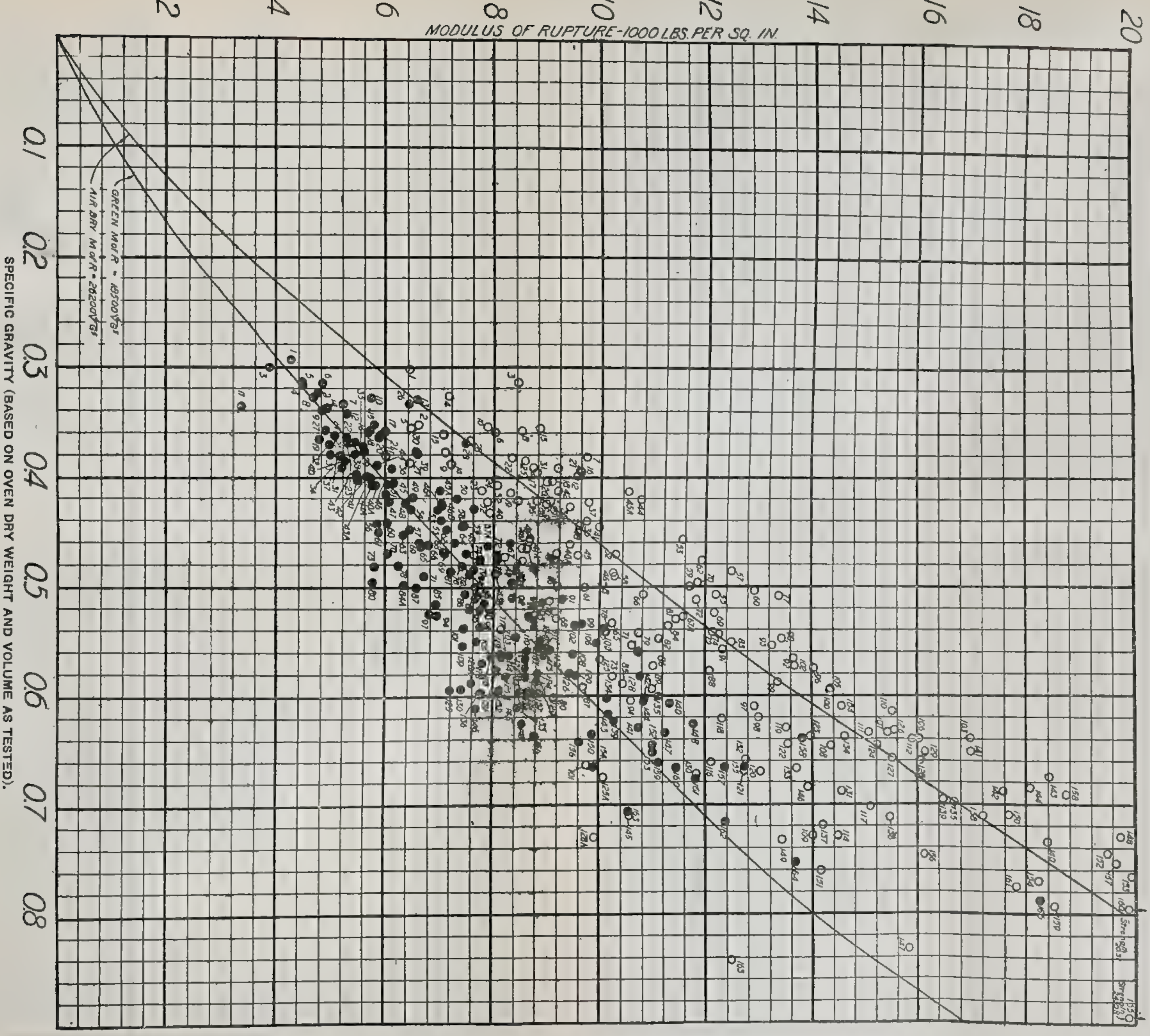

FIG. 5.—Relation of modulus of rupture in static bending to specific gravity.

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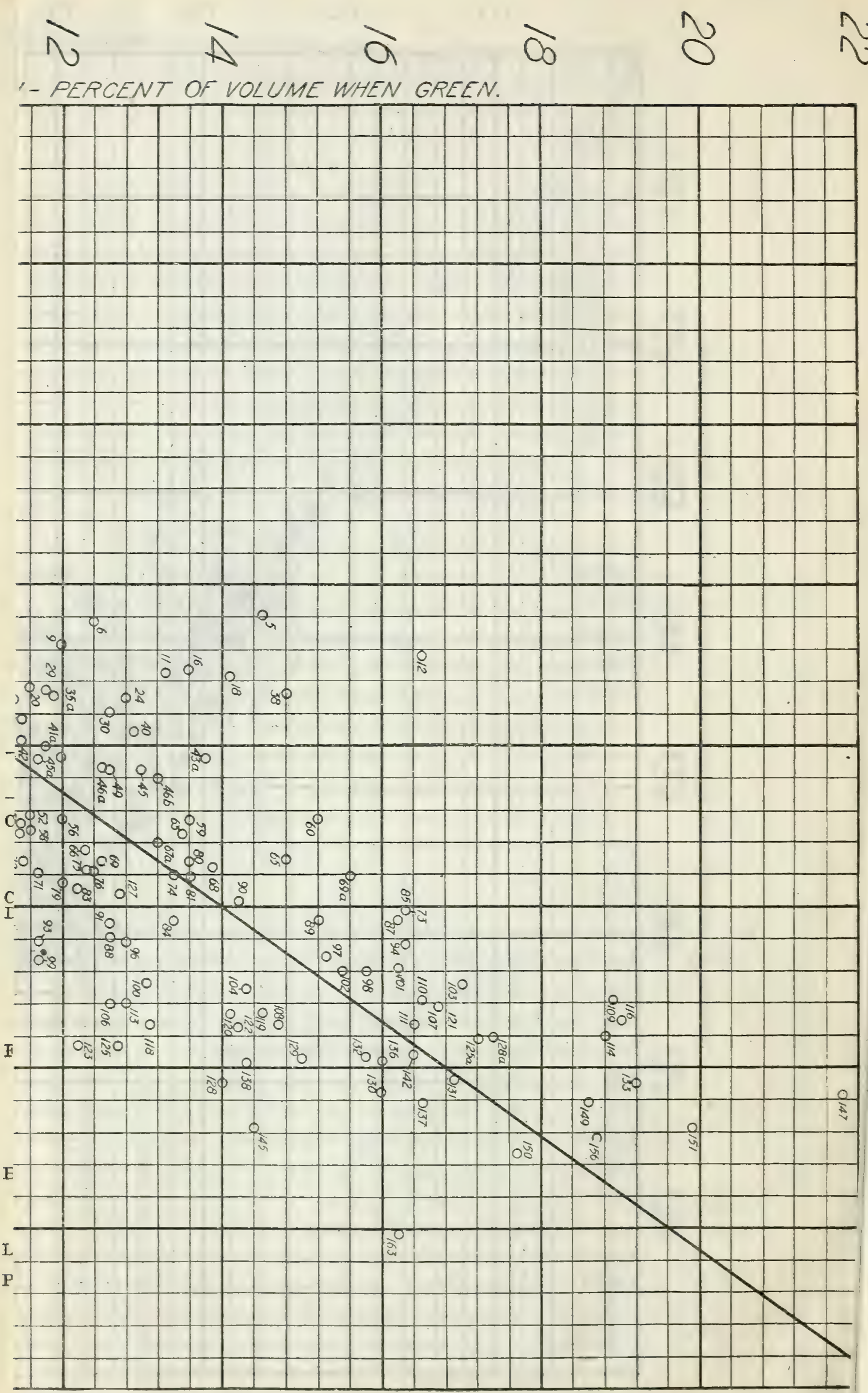
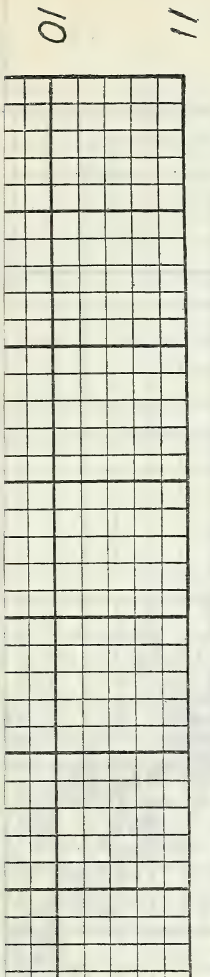


lry conditions to specific gravity.



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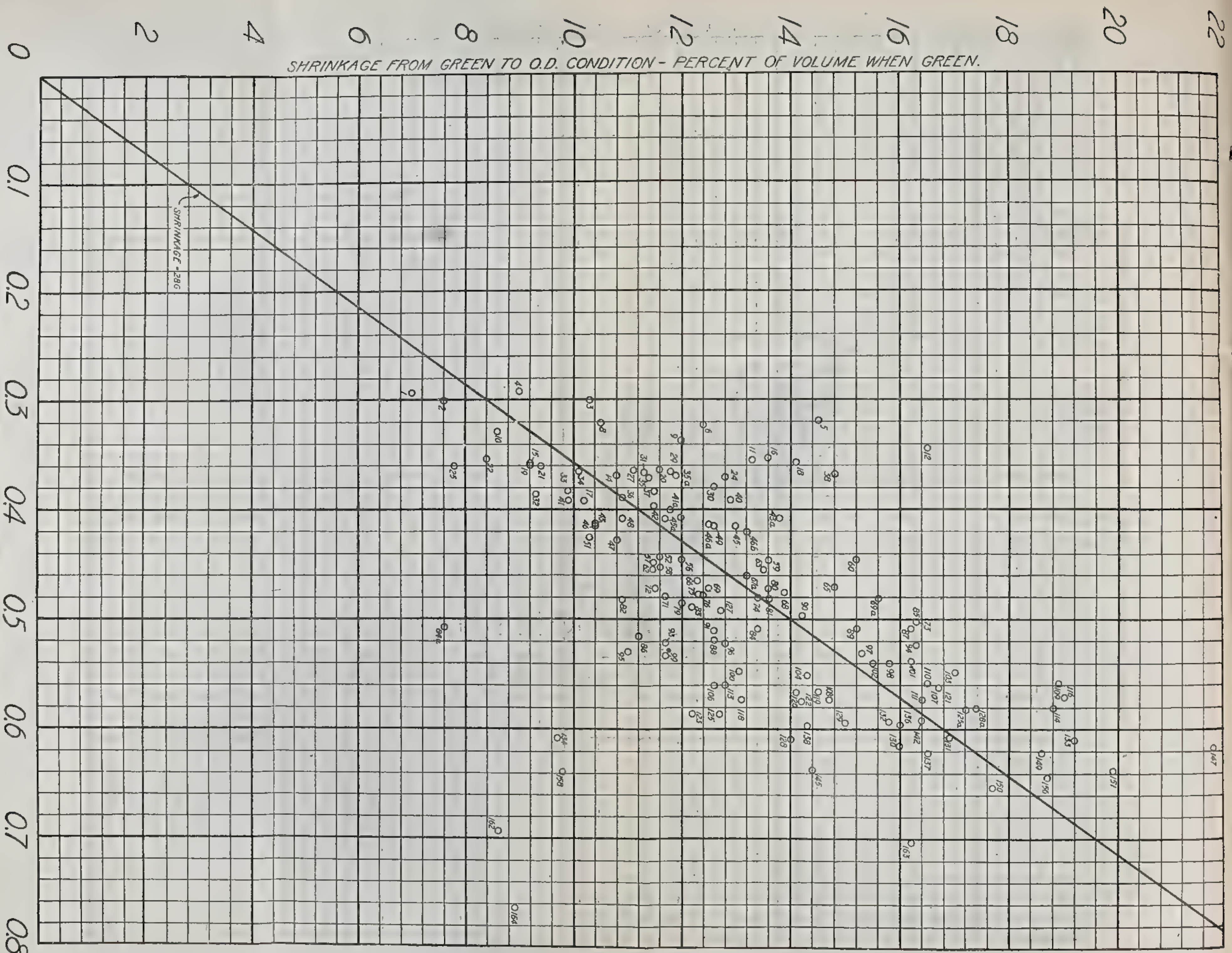


FIG. 6.—Relation of shrinkage from green to oven dry conditions to specific gravity.

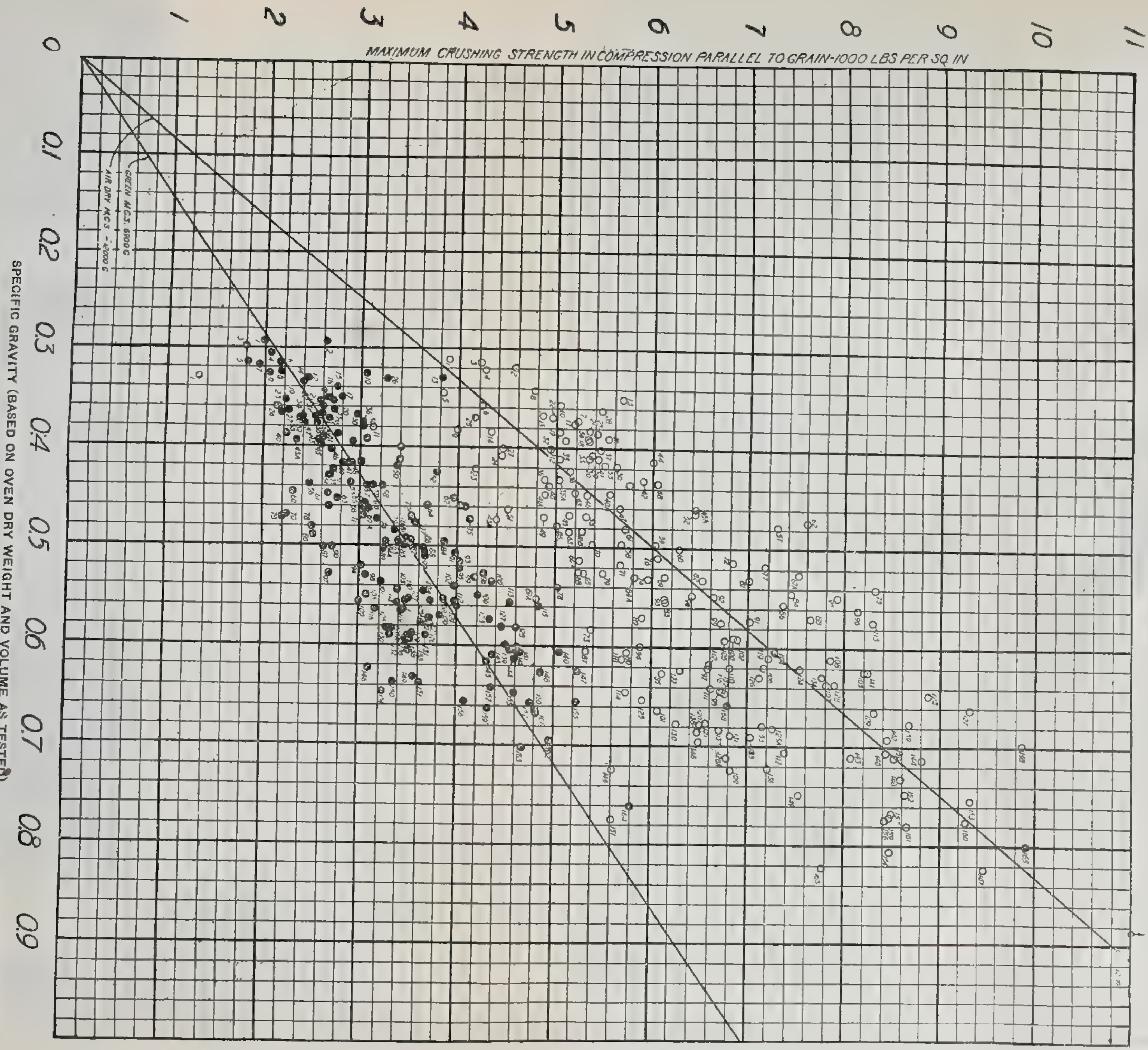
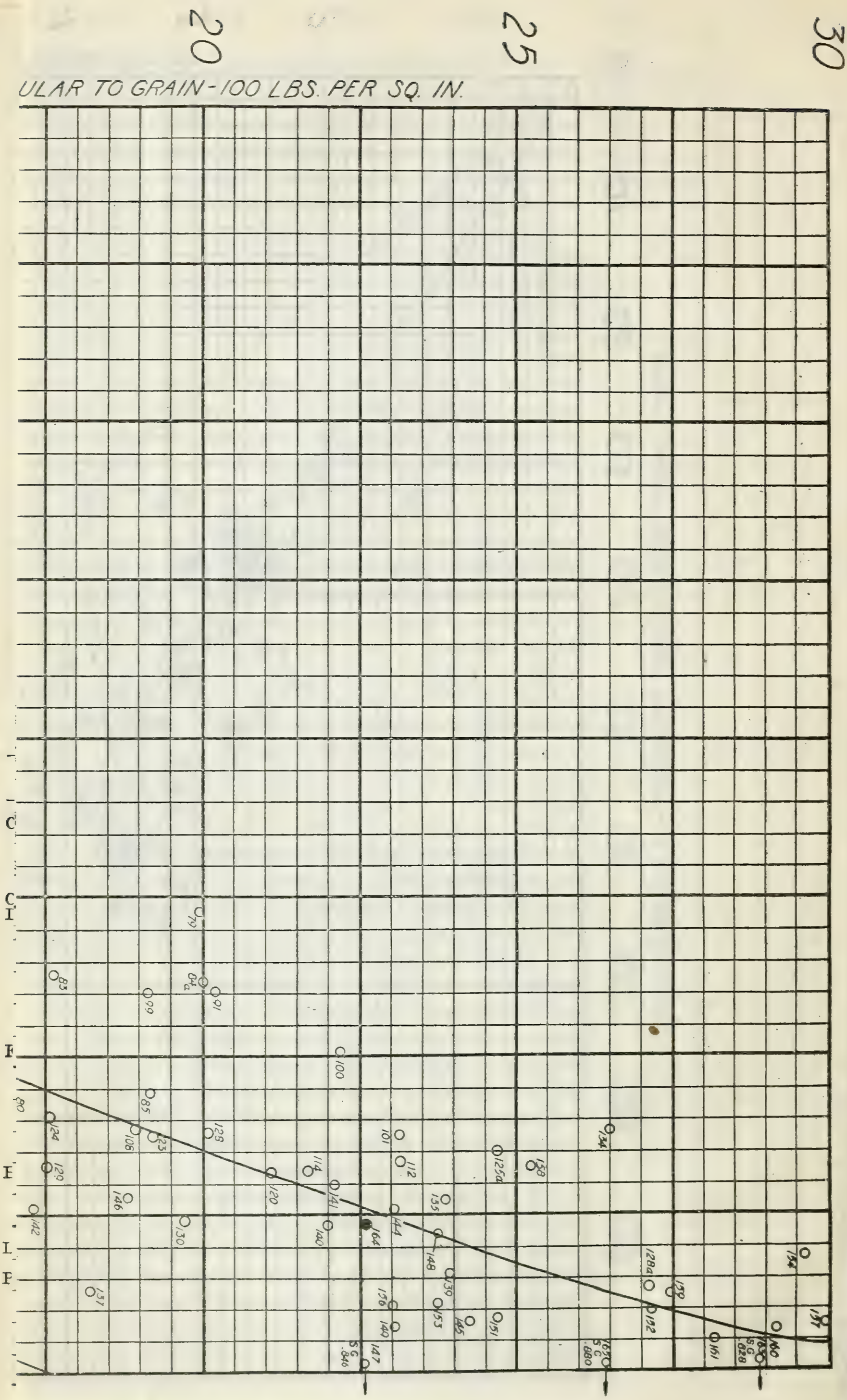
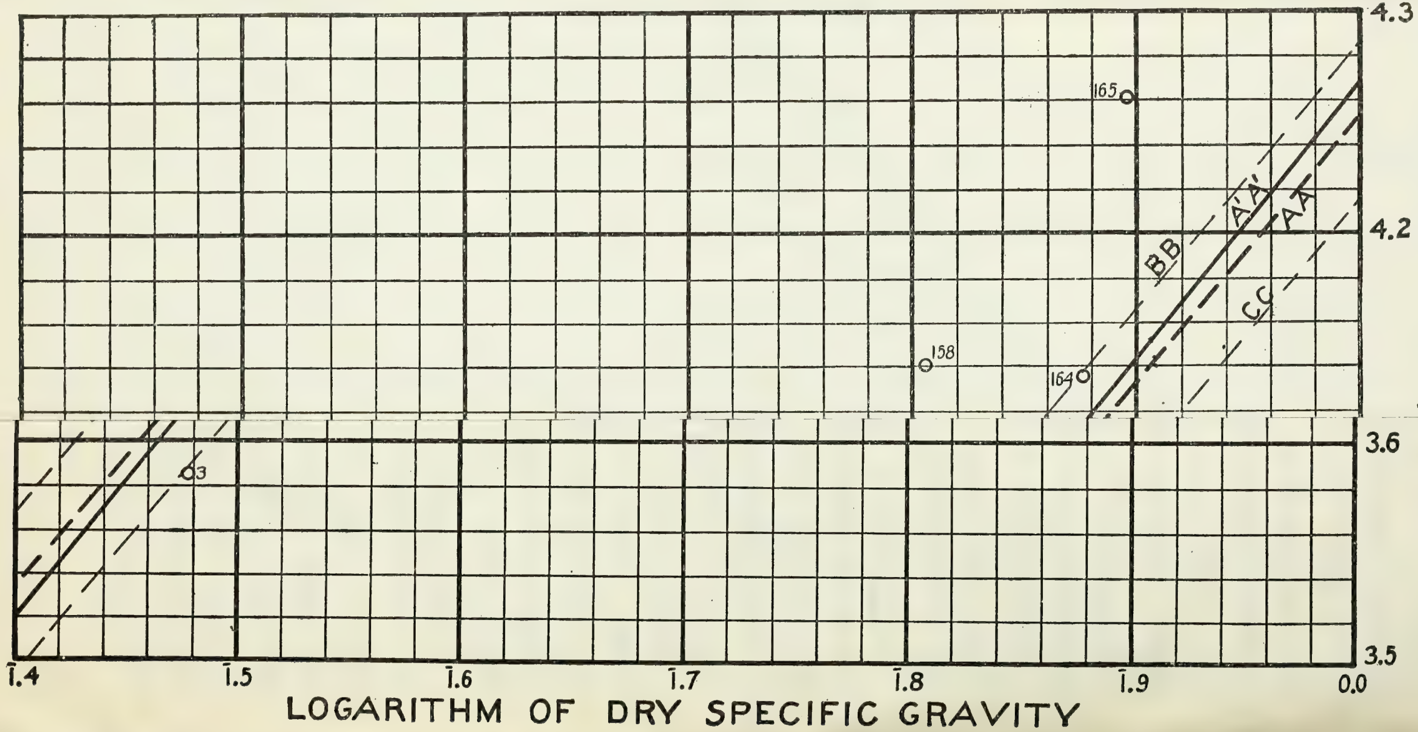


FIG. 7.—Maximum crushing strength in compression parallel to grain to specific gravity.



lar to grain to specific gravity.



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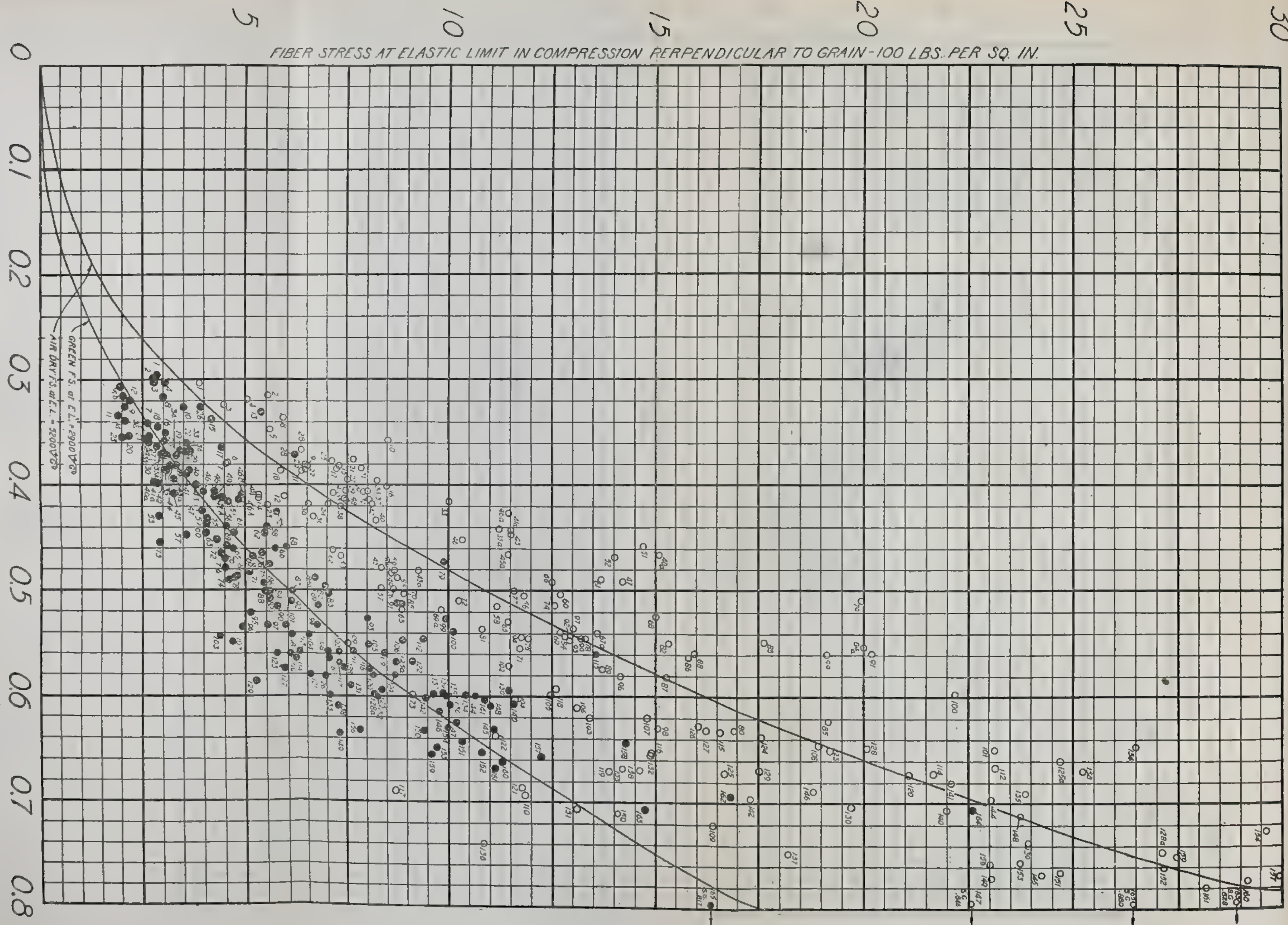

FIG. 8.—Relation of fiber stress at elastic limit in compression perpendicular to grain to specific gravity.

65977°—19. (To back fig. 7.)

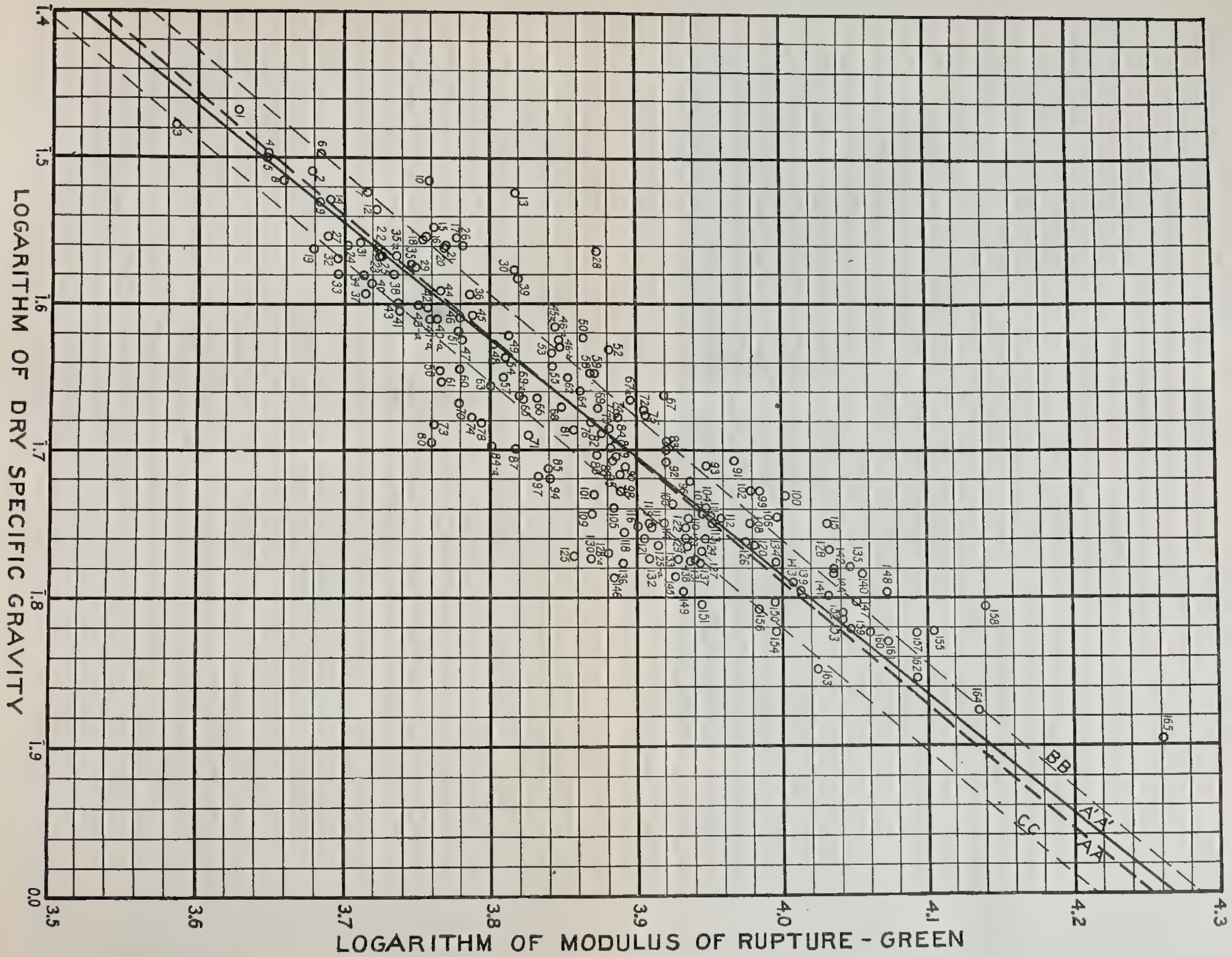
LOGARITHM OF DRY SPECIFIC GRAVITY
LOGARITHM OF MODULUS OF RUPTURE - GREEN
1.4
1.5
1.6
1.7
1.8
1.9
0.0
3.5
3.6
3.7
3.8
3.9
4.0
4.1
4.2
4.3
BB
A'A'
AA
CC

FIG. 9.

APPLICATION OF THE EQUATIONS.

Additional data may possibly necessitate the making of some slight changes in the equations given in Table 1 and the diagrams. However, for comparing species and for determining the best utilization of timber, the value of the equations as they are now is not affected by this possibility. It is to be expected that among a large number of species of widely different structure many will be found which do not satisfy very accurately the average equations connecting the various properties with specific gravity. It is often this variation from an average relation which determines the usefulness of a species for a special purpose.

As an example of the use to which the table and diagrams may be put, suppose it is desired to obtain the strength in compression parallel to the grain of a piece of green hemlock (eastern) grown in the southern Appalachian region. Its specific gravity may be determined by any one of several means which may readily be devised, and we will say that it is found to be 0.38. In the table, the "species-locality" which is probably most nearly representative of the region in question is the eastern hemlock from Tennessee, and of this the maximum crushing strength is 29 per cent above the average for woods of the same specific gravity. To find what an average wood of a specific gravity of 0.38 will stand in compression parallel to the grain, we solve the equation $C=6{,}900\times0.38$, or turn to figure 1 and read from the curve a maximum crushing strength of about 2,600 pounds per square inch. But since the compressive strength of the Tennessee hemlock was 29 per cent high, it is reasonable to expect that the timber in question will also run about 29 per cent high, or that the value would be about 3,300 or 3,400 pounds per square inch ($2{,}600\times1.29=3{,}354$). Any of the other properties of the hemlock under consideration may be estimated in a similar manner.

Again, suppose it is desired to obtain a wood for a use which requires that it be very strong for its weight in its ability to resist a splitting force. Tension perpendicular to grain is the best measure of this. By looking down the column, "Tension, surface of failure radial," it is found that in ability to resist such a force, yellow buckeye is 17 per cent stronger when green and 120 per cent stronger when air-dry than is the average wood of the same specific gravity. It would appear at first that yellow buckeye is the most desirable wood for the purpose, but there is another consideration to be taken into account. Tension perpendicular to the grain varies with the square of the specific gravity; and it must be remembered that those properties (such as tension perpendicular to grain, hardness, work values, and compression perpendicular to the grain) which vary with the higher powers of specific gravity show a large increase in strength

with a comparatively small increase in specific gravity. For instance, a wood with twice the specific gravity of another would be expected to have four times as much strength in tension. Yellow buckeye is a very light wood and woods of more than double its specific gravity may easily be found. Such woods, even though they may run somewhat less in tension strength than the average wood of their weight, may have a tension strength considerably in excess of that of yellow buckeye. Thus, the red oaks, having a specific gravity of about twice that of yellow buckeye, are several times as strong in tension perpendicular to the grain, although they are very little above the average wood of their weight in this respect.

It may be seen from these examples that in comparing different timbers or species, in estimating their various properties, and in finding species with exceptional strength in some properties which may render them valuable for special uses, a knowledge of the specific-gravity strength relations is a valuable aid. It must be borne in mind, however, that such equations can never take the place of tests of species whose properties are unknown. If any particular mechanical property is known, the specific gravity may be approximated and the other properties estimated; even the properties of woods upon which no test data are available can be estimated with a fair degree of accuracy from the results of specific gravity determinations. Nevertheless, it is apparent from a study of the table and diagrams that no one kind of test can replace a complete series of tests.

APPENDIX.

METHOD OF DERIVING EQUATIONS.

In plotting the various points to a natural scale (i. e., the shrinkage or a given mechanical property vs. specific gravity) it was found that in many cases they arranged themselves in the form of a curve, or if their trend was along a straight line, this line would not pass through the origin. Assuming that the function should pass through the origin, i. e., that a piece of wood of zero weight or specific gravity should have zero strength, it was found that in practically every case a curve of the form $f=pG^n$ (where f is the strength value, G the specific gravity, and p and n are constants) would fit the points quite well. This equation is the general equation of the parabola of the nth degree passing through the origin.

In order to simplify the determination of the proper values for the constants p and n the equation was transformed into the logarithmic form, $\log f=\log p+n \log G$. This equation represents a straight line having its slope equal to n and its intercept on the y axis equal to $\log p$. Consequently, to find the constants p and n it is only necessary to plot $\log f$ against $\log G$ on ordinary cross-section paper and find the straight line which best averages the points; then n and $\log p$ are determined from the slope and intercept of this line.

To find the straight line which best averages the points in the logarithmic plot the following plan was adopted:

By successive trials the parallel lines BB and CC (see fig. 9) were so located that 25 per cent of the points were above BB and 25 per cent were below CC and at the same time the vertical distance between the two was a minimum. Two lines (not shown on the figure) were then drawn as follows: Both parallel to BB and CC, one bisecting the distance between them and the other in such a position that 50 per cent of the points were on each side of it. AA was then drawn midway between these two lines and assumed to be the line which best averages the points and best represents the relation between specific gravity and the strength property in question. This method, as can readily be seen, is very likely to produce values of n such that the resulting equations can not be handled without the use of logarithms. As the slope of the lines could in most cases be varied through a considerable angle without appreciably affecting the distance between the lines BB and CC, the slope was so taken that n would be a fraction with the denominator 1, 2, 3, or 4. The solution of the equation is then possible by using the rules for the extraction of square and cube roots. Whenever it happened that more than one direction of the lines BB and CC fulfilled the conditions outlined above, preference was given to that slope which would simplify the form of the equation. The constant p was changed at the same time, so that the new line A^1A^1 passed as nearly through the center of gravity of the points as possible.

The analytical process known as the "method of least squares" can be applied to determining the mathematical relations between two properties of a substance as ascertained from experimental results. This method was used in one or two instances to determine the specific gravity strength relations; but it was found that the long and refined computations essential to the application of this method to so large a number of tests was not justified by the added accuracy of the final determinations. Especially is this true since it is desirable to obtain n to the nearest 0.125 only, and since undue refinement in the value of the constant p is unnecessary in view of the fact that there is a considerable variation of actual results from the values given by any equation which may be derived.

TABLE 1.—*Equations and variations—Specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry.*

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition. In volume.	Shrinkage from green to oven-dry condition. Radial.	Shrinkage from green to oven-dry condition. Tangential.	Static bending. Fiber stress at elastic limit.	Static bending. Modulus of rupture.	Static bending. Modulus of elasticity.	Static bending. Work to elastic limit.	Static bending. Work to maximum load.	Static bending. Total work.	Impact bending, 50-pound hammer. Fiber stress at elastic limit.	Impact bending, 50-pound hammer. Modulus of elasticity.	Impact bending, 50-pound hammer. Work to elastic limit.	Impact bending, 50-pound hammer. Height of drop causing complete failure.	Compression parallel to grain. Fiber stress at elastic limit.	Compression parallel to grain. Maximum crushing strength.	Compression parallel to grain. Modulus of elasticity.	Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: Load required to embed a 0.444-inch ball one-half its diameter. End surface.	Hardness: Load required to embed a 0.444-inch ball one-half its diameter. Radial surface.	Hardness: Load required to embed a 0.444-inch ball one-half its diameter. Tangential surface.	Shear. Surface of failure radial.	Shear. Surface of failure tangential.	Cleavage. Surface of failure radial.	Cleavage. Surface of failure tangential.	Tension. Surface of failure radial.	Tension. Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.
I.—EQUATIONS FOR SHRINKAGE AND FOR EACH OF THE STRENGTH PROPERTIES OF GREEN AND AIR-DRY WOOD IN TERMS OF SPECIFIC GRAVITY.																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Green							$F=10300\sqrt[4]{G^5}$.	$M=18500\sqrt[4]{G^5}$.	$E=2500\ G^1$.	$W=3.51\ G^2$.	$W=42.7\ G^2$.	$W=186.0\ G^2$.	$F=23500\sqrt[4]{G^5}$.	$E=3000\ G^1$.	$W=15.1\ G^2$.	$H=140\ G^2$.	$F=68.0\sqrt{G^5}$.	$C=6900\ G^1$.	$E=2860\ G^1$.	$F=2900\sqrt[4]{G^9}$.	$H=3700\sqrt[4]{G^9}$.	$H=3300\sqrt[4]{G^9}$.	$H=3300\sqrt[4]{G^9}$.	$S=2550\sqrt[3]{G^4}$.	$S=2750\sqrt[3]{G^4}$.	$C=1070\ G^2$.	$C=1300\ G^2$.	$T=1950\ G^2$.	$T=2300\ G^2$.
Green to oven-dry				$S=28\ G^1$.	$S=9.5\ G^1$.	$S=17.0\ G^1$.																							
Air-dry							$F=19000\sqrt[4]{G^5}$.	$M=26200\sqrt[4]{G^5}$.	$E=3000\ G^1$.	$W=9.0\ G^2$.	$W=38.9\ G^2$.	$W=148.0\ G^3$.	$F=35000\sqrt[4]{G^5}$.	$E=3550\ G^1$.	$W=25\ G^2$.	$H=111\ G^2$.	$F=11000\sqrt[4]{G^5}$.	$C=12000\ G^1$.	$E=3500\ G^1$.	$F=5200\sqrt[4]{G^9}$.	$H=4800\sqrt[4]{G^9}$.	$H=3600\sqrt[4]{G^9}$.	$H=3800\sqrt{G^9}$.	$S=3630\sqrt[3]{G^4}$.	$S=4000\sqrt[3]{G^4}$.	$C=1100\ G^2$.	$C=1300\ G^2$.	$T=2100\ G^2$.	$T=2400\ G^2$.

II.—MEASURE OF ACCURACY OF RESPECTIVE EQUATIONS.

Proportion of species-locality.	Percentage of equation value.																											
10 per cent above, per cent	.....	.....	.....	119	128	127	123	114	127	139	149	149	118	122	135	142	130	119	133	136	121	121	120	119	117	130	134	135	140
25 per cent above, per cent	.....	.....	.....	110	116	109	112	108	113	117	123	123	110	109	121	118	115	111	117	115	110	111	111	109	109	118	116	118	127
25 per cent below, per cent	.....	.....	.....	90	88	89	91	91	89	86	83	75	90	90	85	86	86	90	86	88	87	88	90	93	89	83	81	80	74
10 per cent below, per cent	.....	.....	.....	80	77	79	79	84	76	72	70	60	84	80	71	76	73	83	72	77	70	78	81	89	83	68	58	55	51
10 per cent above, per cent	.....	.....	.....	.....	.....	.....	126	113	122	164	139	167	130	120	143	145	145	116	142	133	131	124	120	125	122	144	141	139	141
25 per cent above, per cent	.....	.....	.....	.....	.....	.....	111	106	110	135	117	130	112	110	125	120	127	108	120	118	115	111	112	112	110	126	121	127	122
25 per cent below, per cent	.....	.....	.....	.....	.....	.....	85	89	90	75	83	72	85	89	78	83	82	88	86	83	85	94	91	90	88	78	79	69	85
10 per cent below, per cent	.....	.....	.....	.....	.....	.....	75	80	81	60	66	58	73	81	63	70	68	81	67	74	79	83	83	79	78	56	64	54	54

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE.

Alder, red (Washington):																													
Green	30	.....	.....	119	125	117	122	119	123	139	131	102	119	127	128	117	136	117	138	98	137	119	128	108	110	125	138	139	137
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Ash, Biltmore (Tennessee):																													
Green	91	.....	.....	88	87	80	124	116	104	142	104	88	120	110	130	86	123	114	103	135	121	121	125	124	110	119	109	106	98
Air-dry	.....	.....	.....	.....	.....	.....	131	98	105	160	95	59	117	108	132	132	126	100	100	143	146	135	117	126	98	128	111	130	100
Ash, black (Michigan):																													
Green	60	.....	.....	122	118	103	70	90	100	61	139	144	82	88	81	123	66	76	88	86	100	101	103	100	88	132	86	131	98
Air-dry	.....	.....	.....	.....	.....	.....	128	117	131	92	180	229	.....	.....	.....	174	136	105	115	114	130	114	132	148	106	144	144	124	169
Ash, black (Wisconsin):																													
Green	70	.....	.....	.....	.....	.....	65	84	82	53	142	162	87	69	114	99	.....	91	.....	92	85	92	93	95	83	112	93	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	80	107	94	76	135	177	83	90	88	.....	84	90	93	81	108	102	106	122	100	156	119	144	108
Ash, blue (Kentucky):																													
Green	99	.....	.....	84	77	72	120	113	92	146	121	117	102	87	117	108	115	114	86	144	135	135	138	141	128	96	108	92	101
Air-dry	.....	.....	.....	.....	.....	.....	90	100	82	100	106	129	115	108	123	112	111	97	70	135	135	132	122	112	119	108	112	66	.....

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Ash, green (Louisiana):																													
Green	93	.....	.....	80	.....	.....	99	110	102	94	94	77	112	90	137	86	108	113	101	117	107	105	106	118	102	119	99	119	100
Air-dry	.....	.....	.....	.....	.....	.....	98	106	97	104	104	97	91	95	90	90	91	92	95	95	124	121	107	111	93	90	100	111	79
Ash, pumpkin (Missouri):																													
Green	100	.....	.....	87	90	78	128	118	110	139	104	92	103	98	102	92	126	115	101	139	114	118	124	120	109	103	98	100	87
Air-dry	.....	.....	.....	.....	.....	.....	100	105	99	100	106	80	108	108	108	83	105	97	104	135	125	130	112	135	120	159	126	114	87
Ash, white (Missouri):																													
Green	79	.....	.....	88	80	77	107	101	86	130	94	69	90	82	101	92	103	100	80	180	121	119	112	124	112	124	121	125	101
Air-dry	.....	.....	.....	.....	.....	.....	79	88	81	81	67	60	98	93	117	76	85	89	66	172	122	114	107	134	105	174	114	182	98

Ash, white (Arkansas):																													
Green	106	.....	.....	80	82	69	104	111	101	100	151	112	105	95	109	79	109	111	97	119	114	109	117	119	106	100	89	111	98
Air-dry	.....	.....	.....	.....	.....	.....	105	114	106	102	101	122	78	88	69	81	103	98	88	76	130	128	110	120	101	161	100	132	74
Ash, white (West Virginia):																													
Green	83	.....	.....	92	87	79	107	108	103	111	130	115	119	101	140	111	105	99	104	114	123	125	124	121	86	111	117	117	113
Air-dry	.....	.....	.....	.....	.....	.....	106	100	102	119	113	120	115	99	145	111	98	92	100	130	140	126	124	135	100	118	58	150	117
Ash, white (New York):																													
Green	128	.....	.....	82	96	88	116	113	111	108	111	92	114	102	115	99	111	115	103	96	106	112	111	129	119	103	105	106	112
Air-dry	.....	.....	.....	.....	.....	.....	118	105	102	130	104	76	116	108	121	99	137	103	94	106	121	117	126	125	111	109	80	142	98
Aspen (Wisconsin):																													
Green	23	.....	.....	106	96	113	98	99	90	135	117	125	100	96	121	144	86	87	75	72	69	92	93	87	89	72	68	70	55
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Aspen, largetooth (Wisconsin):																													
Green	20	.....	.....	114	92	132	109	111	129	106	106	86	112	107	135	96	115	111	124	96	132	121	124	114	120	130	135	135	144
Air-dry	.....	.....	.....	.....	.....	.....	117	107	135	128	104	128	131	122	166	146	143	110	121	106	114	100	98	104	121	100	131	101	100
Basswood (Pennsylvania):																													
Green	12	.....	.....	171	215	176	105	108	133	98	97	108	106	112	120	104	120	107	152	98	94	95	96	97	100	106	105	103	123
Air-dry	.....	.....	.....	.....	.....	.....	135	115	127	177	177	172	140	136	180	137	165	102	128	85	93	90	97	104	105	161	149	71	150
Basswood (Wisconsin):																													
Green	5	.....	.....	162	206	156	101	101	106	126	135	102	97	97	122	114	73	84	113	96	103	96	93	101	103	115	130	117	132
Air-dry	.....	.....	.....	.....	.....	.....	113	90	157	108	64	91	62	108	51	55	75	93	185	117	108	123	115	150	158	159	194	108	144
Beech (Indiana):																													
Green	110	.....	.....	105	87	111	90	96	96	86	106	81	103	90	108	98	107	91	91	77	104	104	106	98	108	97	130	102	135
Air-dry	.....	.....	.....	.....	.....	.....	78	108	99	67	110	123	92	94	87	98	67	93	97	52	87	98	94	98	96	128	123	132	140
Beech (Pennsylvania):																													
Green	98	.....	.....	105	101	118	95	91	84	100	88	69	83	87	74	92	76	84	80	83	102	95	96	97	100	104	117	106	122
Air-dry	.....	.....	.....	.....	.....	.....	93	90	83	104	73	71	105	101	110	73	90	87	84	82	83	97	94	103	101	90	110	106	50
Birch, paper (Wisconsin):																													
Green	73	.....	.....	116	147	109	70	78	84	59	151	146	82	82	77	137	62	68	71	61	56	77	76	78	78	87	83	92	66
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Birch, sweet (Pennsylvania:																													
Green	129	.....	.....	90	113	76	86	91	102	62	107	86	81	97	62	94	76	88	101	61	88	84	90	94	98	83	86	73	84
Air-dry	.....	.....	.....	.....	.....	.....	119	105	109	121	102	53	132	117	128	106	109	109	150	83	110	103	107	134	120	96	102	.....	61
Birch, yellow (Pennsylvania):																													
Green	107	.....	.....	106	131	94	100	99	107	90	144	125	110	100	115	106	91	92	95	62	83	85	86	93	91	88	88	76	74
Air-dry	.....	.....	.....	.....	.....	.....	105	104	106	102	144	88	119	118	114	142	129	102	82	83	93	104	101	103	118	66	123	55	88
Birch, yellow (Wisconsin):																													
Green	103	.....	.....	111	152	97	86	97	117	59	112	85	96	107	80	81	81	90	123	59	87	91	88	93	86	83	71	72	72
Air-dry	.....	.....	.....	.....	.....	.....	127	118	129	123	119	119	97	109	88	130	121	110	108	76	90	104	97	73	73	96	121	142	123

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content. Per cent.	Shrinkage from green to oven-dry condition: In volume. Per cent of dimensions when green.	Shrinkage from green to oven-dry condition: Radial. Per cent of dimensions when green.	Shrinkage from green to oven-dry condition: Tangential. Per cent of dimensions when green.	Static bending: Fiber stress at elastic limit. Lbs. per sq. in.	Static bending: Modulus of rupture. Lbs. per sq. in.	Static bending: Modulus of elasticity. 1,000s of lbs. per sq. in.	Static bending: Work to elastic limit. Inch lbs. per cu. in.	Static bending: Work to maximum load. Inch lbs. per cu. in.	Static bending: Total work. Inch lbs. per cu. in.	Impact bending, 50-pound hammer: Fiber stress at elastic limit. Lbs. per sq. in.	Impact bending, 50-pound hammer: Modulus of elasticity. 1,000s of lbs. per sq. in.	Impact bending, 50-pound hammer: Work to elastic limit. Inch lbs. per cu. in.	Impact bending, 50-pound hammer: Height of drop causing complete failure. Inches.	Compression parallel to grain: Fiber stress at elastic limit. Lbs. per sq. in.	Compression parallel to grain: Maximum crushing strength. Lbs. per sq. in.	Compression parallel to grain: Modulus of elasticity. 1,000s of lbs. per sq. in.	Compression perpendicular to grain, fiber stress at elastic limit. Lbs. per sq. in.	Hardness: load required to embed a 0.444-inch ball one-half its diameter: End surface. Lbs.	Hardness: Radial surface. Lbs.	Hardness: Tangential surface. Lbs.	Shear: Surface of failure radial. Lbs. per sq. in.	Shear: Surface of failure tangential. Lbs. per sq. in.	Cleavage: Surface of failure radial. Lbs.	Cleavage: Surface of failure tangential. Lbs.	Tension: Surface of failure radial. Lbs. per sq. in.	Tension: Surface of failure tangential. Lbs. per sq. in.
III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Buckeye, yellow (Tennessee):																													
Green	9	.....	.....	127	113	141	99	100	115	100	109	92	105	112	121	112	99	91	106	88	121	110	108	122	112	119	139	117	142
Air-dry	.....	.....	.....	.....	.....	.....	124	92	113	174	110	100	121	107	175	90	128	87	138	182	99	94	96	110	107	128	174	220	182
Buckthorn, cascara (Oregon):																													
Green	84a	.....	.....	54	68	55	77	82	50	117	125	185	85	76	91	157	67	96	70	114	90	112	105	118	95	83	81	101	85
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Butternut (Tennessee):																													
Green	27	.....	.....	109	87	105	91	95	104	94	145	162	119	118	144	148	95	90	85	94	106	108	119	106	119	139	157	167	169
Air-dry	.....	.....	.....	.....	.....	.....	103	81	104	132	156	266	109	122	121	151	128	92	133	117	104	105	119	118	119	102	110	114	151

Butternut (Wisconsin):																													
Green	21	.....	.....	93	107	95	108	113	110	130	149	177	107	110	123	121	115	106	123	90	112	121	121	114	115	154	145	159	159
Air-dry	.....	.....	.....	.....	.....	.....	144	111	111	210	117	.....	130	117	183	130	.....	117	92	130	97	106	110	131	134	121	135	116	125
Chinquapin, western (Oregon):																													
Green	466	.....	.....	112	116	105	119	110	95	169	123	106	110	100	128	126	85	105	128	125	135	137	114	119	124	108	110	137	121
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cherry, black (Pennsylvania):																													
Green	72	.....	.....	87	82	89	103	111	111	102	135	125	110	105	123	107	111	109	114	86	117	121	112	115	117	119	128	114	130
Air-dry	.....	.....	.....	.....	.....	.....	133	104	101	193	106	71	95	109	86	94	153	111	111	90	154	114	139	110	128	138	81	92	87
Cherry, wild red (Tennessee):																													
Green	24	.....	.....	124	81	168	99	96	115	100	110	137	98	107	105	118	96	87	103	90	110	108	112	93	101	109	106	104	106
Air-dry	.....	.....	.....	.....	.....	.....	126	95	115	174	144	270	106	110	125	196	152	90	100	96	139	119	112	109	106	125	132	87	90
Chestnut (Maryland):																													
Green	46	.....	.....	90	86	97	97	100	93	110	104	114	106	110	108	102	100	97	86	105	108	93	100	117	100	128	125	149	132
Air-dry	.....	.....	.....	.....	.....	.....	112	104	103	142	82	79	90	100	97	85	115	128	102	119	101	108	105	95	85	112	93	113	94
Chestnut (Tennessee):																													
Green	40	.....	.....	118	92	103	90	93	94	100	106	103	104	98	124	107	91	83	86	107	116	105	110	103	89	130	111	123	112
Air-dry	.....	.....	.....	.....	.....	.....	104	87	97	137	86	132	99	87	132	96	108	94	89	104	106	99	96	103	94	133	111	110	127
Cottonwood, black (Washington):																													
Green	6	.....	.....	109	120	161	117	111	135	121	118	149	119	124	144	139	111	99	126	93	101	103	106	100	105	125	146	117	132
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cucumber tree (Tennessee):																													
Green	59	.....	.....	109	124	118	112	110	140	94	119	101	109	127	100	111	114	103	133	90	93	93	90	105	117	110	112	107	106
Air-dry	.....	.....	.....	.....	.....	.....	133	106	129	144	137	128	126	137	130	144	132	101	143	86	103	93	95	99	111	117	99	123	182
Dogwood, flowering (Tennessee):																													
Green	151	.....	.....	111	116	104	82	84	74	77	121	94	52	43	56	99	.....	83	.....	95	104	118	115	102	103	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	87	76	74	90	83	61	76	75	68	60	76	60	67	87	105	123	114	.....	96	71	101	137	.....
Dogwood, western (Oregon):																													
Green	125a	.....	.....	106	116	97	80	88	75	77	117	89	82	87	71	119	66	91	93	106	112	110	106	98	105	78	86	104	102
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Elder, pale (Oregon):																													
Green	69a	.....	.....	116	99	115	87	94	78	96	97	149	85	88	85	120	95	95	111	99	124	135	135	115	105	139	96	126	108
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Elm, cork (Wisconsin, Marathon County):																													
Green	126	.....	.....	.....	.....	.....	83	101	85	77	137	111	101	79	128	101	.....	94	.....	83	89	93	94	99	101	76	87	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	75	105	93	59	131	113	94	94	91	120	79	94	87	88	90	98	93	107	103	103	114	121	120

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Elm, cork (Wisconsin, Rusk County):																													
Green	120	.....	.....	89	89	84	93	102	80	100	139	122	90	92	78	108	86	97	84	95	100	108	108	97	97	104	88	97	83
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Elm, slippery (Indiana):																													
Green	102	.....	.....	103	99	107	118	113	98	130	95	126	109	99	115	102	108	106	94	92	112	104	94	110	99	128	115	142	128
Air-dry	.....	.....	.....	.....	.....	.....	84	105	95	76	111	150	92	86	97	105	82	97	83	77	100	112	89	112	109	142	121	127	120
Elm, slippery (Wisconsin):																													
Green	74	.....	.....	100	108	108	92	105	101	90	164	172	94	95	94	156	102	97	95	80	106	108	111	120	106	151	131	143	119
Air-dry	.....	.....	.....	.....	.....	.....	109	100	95	132	154	207	112	100	135	147	111	94	99	108	101	93	104	110	102	95	83	81	45

Elm, white (Pennsylvania):																													
Green	55			112	101	129	103	104	93	121	132	128	96	97	100	126	95	97	102	93	109	106	110	101	106	132	132	135	138
Air-dry							120	107	98	166	137	161	116	92	169	172	115	88	70	85	120	109	114	121	120	121	117	121	98
Elm, white (Wisconsin):																													
Green	53						79	107	97	67	149	142	109	81	146	112		92		69	96	93	100	94	87	96	112		
Air-dry							95	118	110	94	162	166	108	97	135	147	95	95	126	77	102	106	102	100	110	135	112	137	126
Greenheart:																													
Green	165			57	76	62	179	132	142	174	45	23	131	139	95	44		180		88	69	85	83	87	100	61	51		50
Air-dry							126	105	128	100	55	35	96	117	64	56	116	117	127	67	49	72	65	62	51				
Gum, black (Tennessee):																													
Green	68			105	100	98	101	98	88	117	85	77	105	95	117	94	94	95	72	119	112	106	102	105	116	119	123	117	121
Air-dry							108	78	80	154	51	77	110	96	132	64	82	83	81	122	114	100	90	89	92	86	115	79	76
Gum, blue (California):																													
Green	147			130	127	143	129	107	126	114	81	68	107	128	79	71	129	121	128	100	102	123	114	98	116	71	80	63	88
Air-dry																													
Gum, cotton (Louisiana):																													
Green	76			93	97	98	104	100	87	122	79	80	83	92	73	77	86	108	94	81	113	106	117	103	105	108	130	108	152
Air-dry							76	80	84	76	53	58	74	83	73	61	80	99	85	79	114	106	103	98	109	130	112	82	122
Gum, red (Missouri):																													
Green	54						95	99	105								113	90											
Air-dry																													
Hackberry (Indiana):																													
Green	90			101	88	104	74	96	97	59	174	166	109	96	123	146	95	96	74	92	104	114	110	111	109	157	142	144	142
Air-dry							81	109	87	79	156	149	105	98	115	193	83	97	90	100	121	126	121	104	104	95	115	101	104
Hackberry (Wisconsin):																													
Green	78			103	106	109	69	84	76	71	136	129	77	74	80	137	71	76	67	81	103	106	108	106	105	121	114	124	121
Air-dry							77	83	75	85	97	130	95	79	117	113	82	78	58	100	92	90	97	103	108	86	91	66	94
Haw, pear (Wisconsin):																													
Green	146						70	76	63	66	142	114						72		100	95	108	104	96	96				
Air-dry							76	85	67	79	130	69	62	76	46	39	68	78	52	85	104	101	105	88					
Hickory, big shellbark (Mississippi):																													
Green	135						117	113	103	114	156	164	111	98	114	156	100	87	97	108				88	85				
Air-dry							85	100	96	70	112	128	116	107	125	137		85		106				107	112				
Hickory, big shellbark (Ohio):																													
Green	154						77	89	66	79	190	161	101	74	117	210	48	73	68	96				74	83				
Air-dry							68	96	90	40	100			88		138		96		117				92	73				
Hickory, bitternut (Ohio):																													
Green	139						96	100	90	88	120	142	130	94	162	135	120	110	94	108				91	99				
Air-dry							85	99	90	74	94	152	123	120	122	132		107		90				95					

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Hickory, mockernut (Mississippi):																													
Green	144						107	110	107	94	118	119	126	104	142	98	98	109	96	117				98	107				
Air-dry							108	110	104	104	101	123	90	106	81	90		102		100				89	83				
Hickory, mockernut (Pennsylvania):																													
Green	159						106	101	91	96	168	135	110	102	103	196	98	94	72	85				87	84				
Air-dry							100	94	107	72	98	114	83	88	65	118		89		96									
Hickory, mockernut (West Virginia):																													
Green	155						111	114	113	90	127	156					130	116	80										
Air-dry																													

Hickory, nutmeg (Mississippi):																													
Green	112	.....	.....	.....	.....	.....	97	101	92	96	169	149	115	88	138	130	111	104	89	125	.....	.....	.....	90	86	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	88	110	98	72	172	.....	.....	.....	.....	.....	.....	89	.....	109	.....	.....	.....	110	.....	.....	.....	.....	.....
Hickory, pignut (Mississippi):																													
Green	148	.....	.....	.....	.....	.....	112	114	106	102	145	121	114	88	125	150	92	113	82	114	.....	.....	.....	79	74	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	100	111	115	79	114	114	113	112	110	107	.....	98	.....	100	.....	.....	.....	.....	102	.....	.....	.....	.....
Hickory, pignut (Ohio):																													
Green	157	.....	.....	.....	.....	.....	110	110	93	108	144	140	105	72	138	182	102	105	90	108	.....	.....	.....	93	113	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	87	106	110	67	101	122	107	123	87	152	.....	92	.....	102	.....	.....	.....	125	115	.....	.....	.....	.....
Hickory, pignut (Pennsylvania):																													
Green	160	.....	.....	.....	.....	.....	99	103	96	86	182	138	112	97	112	149	105	105	100	98	.....	.....	.....	87	87	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	91	103	100	69	137	139	103	104	90	100	.....	99	.....	100	.....	.....	.....	85	78	.....	.....	.....	.....
Hickory, pignut (West Virginia):																													
Green	161	.....	.....	.....	.....	.....	92	104	104	69	156	132	131	95	146	110	87	104	104	94	.....	.....	.....	86	87	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	94	94	103	77	128	.....	.....	115	.....	92	.....	93	.....	94	.....	.....	.....	90	85	.....	.....	.....	.....
Hickory, shagbark (Mississippi):																													
Green	140	.....	.....	.....	.....	.....	112	114	107	102	106	130	111	95	115	97	115	121	108	121	.....	.....	.....	90	91	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	94	103	102	81	97	128	93	100	85	113	.....	99	.....	92	.....	.....	.....	122	112	.....	.....	.....	.....
Hickory, shagbark (Ohio):																													
Green	152	.....	.....	.....	.....	.....	91	103	83	86	190	149	92	84	88	174	73	98	81	96	.....	.....	.....	94	99	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	76	107	95	51	137	.....	.....	97	.....	119	.....	96	.....	96	.....	.....	.....	.....	81	.....	.....	.....	.....
Hickory, shagbark (Pennsylvania):																													
Green	143	.....	.....	.....	.....	.....	104	100	90	121	74	146	.....	.....	.....	.....	76	103	59	.....	.....	.....	.....	.....	87	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	120	115	93	163	94	.....	.....	.....	.....	.....	.....	95	.....	94	.....	.....	.....	.....	.....	.....	.....	.....	.....
Hickory, shagbark (West Virginia):																													
Green	153	.....	.....	.....	.....	.....	101	101	107	81	100	121	114	100	110	98	95	103	105	88	.....	.....	.....	84	82	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	98	106	108	77	114	.....	101	106	87	106	.....	103	.....	86	.....	.....	.....	94	93	.....	.....	.....	.....
Hickory, water (Mississippi):																													
Green	141	.....	.....	.....	.....	.....	103	103	99	92	111	98	104	93	102	101	90	112	111	117	.....	.....	.....	102	101	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	105	111	111	93	117	110	.....	107	.....	106	.....	109	.....	100	.....	.....	.....	.....	80	.....	.....	.....	.....
Holly, American (Tennessee):																													
Green	87	.....	.....	114	94	111	78	84	71	81	100	114	89	70	116	144	69	76	60	100	112	114	119	98	114	102	132	95	128
Air-dry	.....	.....	.....	.....	.....	.....	81	72	69	95	77	40	85	77	104	76	76	73	62	100	121	102	110	98	128	113	.....	132	74
Hornbeam (Tennessee):																													
Green	149	.....	.....	107	135	89	79	83	74	74	80	76	78	94	56	126	69	82	75	71	76	88	85	94	94	72	62	56	47
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Laurel, mountain (Tennessee):																													
Green	145	.....	.....	81	95	84	104	85	60	154	79	58	76	59	86	57	.....	101	.....	108	112	117	118	116	113	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	88	62	66	105	46	30	75	71	71	79	72	65	62	85	112	128	119	.....	.....	.....	.....	.....	.....

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.
III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.																													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Locust, black (Tennessee):																													
Green	158	.....	.....	55	70	62	148	130	115	164	88	80	130	120	121	73	155	149	102	130	100	102	114	133	100	71	83	88	83
Air-dry	.....	.....	.....	.....	.....	.....	115	113	101	124	102	125	97	105	84	110	111	117	168	119	61	86	93	107	123	58	55	63	52
Locust, honey (Indiana):																													
Green	162	.....	.....	46	.....	.....	88	101	96	71	79	83	87	99	61	76	100	104	78	132	114	128	125	115	119	96	92	114	123
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Madrona (California):																													
Green	101	.....	.....	108	101	128	98	87	79	111	64	40	74	88	58	68	85	87	66	85	105	94	94	106	103	112	94	112	106
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Madrona (Oregon):																													
Green	128a	.....	.....	108	99	120	88	80	57	121	81	45	87	70	97	85	66	83	78	91	108	103	99	113	110	106	104	104	102
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Magnolia (Louisiana):																													
Green	66			95	123	85	92	96	90	88	167	154	100	102	103	186	86	85	98	112	119	128	125	110	115	113	157	121	156
Air-dry							96	96	97	104	121	72	101	95	118	90	83	85	127	190	132	135	132	124	100	190	119	135	138
Maple, Oregon (Washington):																													
Green	58			91	89	95	117	110	98	146	103	72	99	110	93	84	98	107	99	121	130	121	121	122	123	126	144	132	151
Air-dry																													
Maple, red (Pennsylvania):																													
Green	69			95	86	103	94	103	118	76	120	96	110	107	118	104	97	97	119	90	114	108	110	109	120	119	139	122	132
Air-dry							113	104	109	130	121	135	107	110	112	100	114	97	91	98	117	102	99	122	135	139	149	66	104
Maple, red (Wisconsin):																													
Green	92						100	104	113	85	88	55	119	95	146	83		104		100	90	85	85	106	115	99	94		
Air-dry							93	106	104	84	98	80	103	97	113	94	98	101	98	98	114	101	102	104	106	135	130	102	135
Maple, silver (Wisconsin):																													
Green	56			96	72	97	83	87	85	88	132	107	82	80	92	110	81	82	86	100	112	112	112	116	124	132	132	133	149
Air-dry							112	82	85	133	86	91	110	86	171	100	128	87	68	106	145	100	109	118	129	132	137	69	125
Maple, sugar (Indiana):																													
Green	104			93	94	98	95	101	106	83	98	85	105	103	102	90	96	97	94	90	103	108	110	105	119	112	132	106	126
Air-dry							100	103	100	103	85	81	84	95	76	74	87	100	95	59	123	112	114	111	130	100	95	52	108
Maple, sugar (Pennsylvania):																													
Green	108			92	91	97	114	105	108	111	100	92	106	96	110	93	98	101	84	90	108	108	108	107	115	108	117	104	128
Air-dry							107	95	90	122	89	64	116	112	116	89	117	101	80	98	114	114	116	132	132	108	154	104	74
Maple, sugar (Wisconsin):																													
Green	124						89	95	99	72	68	38	120	94	142	63		103		104	89	86	85	109	115	95	104		
Air-dry							86	104	103	70	90	62	94	94	94	73	90	101	98	92	112	104	107	108	110	140	138		
Oak, bur (Wisconsin):																													
Green	125			77	80	90	68	75	59	71	72	67	79	66	85	85	68	82	52	102	100	108	110	98	101	95	97	100	106
Air-dry							62	63	54	71	56	45	74	66	79	56	58	76	59	79	72	94	94	80	95	45	72	48	83
Oak, California black (California):																													
Green	80			103	88	77	75	75	63	92	71	42	84	84	83	80	64	75	66	116	106	108	106	96	91	108	113	109	119
Air-dry																													
Oak, canyon live (California):																													
Green	163			82	119	119	95	88	76	94	67	46	75	86	55	71	93	97	78	110	96	108	105	100	109	81	100	83	108
Air-dry																													
Oak, chestnut (Tennessee):																													
Green	121			106	101	100	90	87	95	77	67	53	99	101	89	73	86	91	94	77	90	96	92	93	94	81	102	86	102
Air-dry							93	81	82	97	66	53	101	119	83	87	79	81	98	53	67	81	77	65	79	45	95		142
Oak, cow (Louisiana):																													
Green	133			114	104	91	90	88	91	80	85	76	84	106	61	90	87	87	89	77	96	110	109	91	98	83	102	85	93
Air-dry							65	87	90	44	68	49	86	105	66	76	65	88	92	115	64	85	79	98	86	45	71	56	68

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Oak, laurel (Louisiana):																													
Green	116	.....	.....	119	73	99	89	88	98	76	83	61	90	108	72	89	82	81	94	88	102	112	110	96	97	92	109	104	126
Air-dry	.....	.....	.....	.....	.....	.....	77	78	89	64	70	91	78	106	60	91	83	87	117	130	71	95	92	95	104	77	73	83	95
Oak, post (Arkansas):																													
Green	130	.....	.....	93	101	105	88	76	61	110	60	38	89	88	79	74	80	82	63	125	97	102	104	91	99	86	101	100	108
Air-dry	.....	.....	.....	.....	.....	.....	68	74	66	66	56	45	72	81	59	80	51	77	77	85	72	96	84	83	72	74	76	55	90
Oak, post (Louisiana):																													
Green	137	.....	.....	95	91	87	96	90	84	97	86	64	84	95	67	95	81	87	83	106	100	116	112	93	93	89	94	92	102
Air-dry	.....	.....	.....	.....	.....	.....	62	81	82	43	83	128	90	83	87	95	66	82	97	132	62	100	81	82	85	55	92	54	85
Oak, red (Arkansas):																													
Green	119	.....	.....	91	78	86	77	89	88	63	94	101	93	92	87	94	76	88	82	107	110	114	114	101	94	102	107	106	118
Air-dry	.....	.....	.....	.....	.....	.....	98	92	105	92	81	120	92	92	88	93	69	99	128	66	92	110	112	102	102	85	110	108	136

Oak, red (Indiana):																													
Green	118			82	69	87	68	85	89	52	83	62	91	89	86	80	69	82	80	98	108	110	108	94	94	105	112	102	119
Air-dry							60	85	90	40	77	71	85	83	85	71	51	77	89	69	81	93	100	87	89	72	77	59	96
Oak, red (Louisiana):																													
Green	117						86	90	104	66	72	64	89	107	68	89	81	89	119	85	96	104	104	88	82	102	100	110	107
Air-dry							77	89	98	55	74	66	113	103	116	102	83	87	92	36	112	83	77	77	78	107	104		
Oak, red (Tennessee):																													
Green	97			103	74	92	70	83	90	56	103	100	95	95	91	121	60	74	82	79	100	112	107	92	90	116	115	114	121
Air-dry							82	90	95	72	100	130	101	111	93	119	97	88	80	71	85	98	90	93	83	50	92	85	92
Oak, highland Spanish (Louisiana):																													
Green	94			112	91	98	91	84	86	94	68	46	90	100	79	80	73	84	92	96	100	104	110	97	76	101	83	95	79
Air-dry							63	76	86	48	67	46	88	82	90	65	53	82	179	111	71	102	95	59	96	68	95	55	71
Oak, lowland Spanish (Louisiana):																													
Green	142			99	90	104	117	110	118	102	94	78	95	123	66	100	103	111	117	100	106	121	117	96	94	93	104	91	104
Air-dry							100	107	113	82	101	72	114	113	110	93	101	101	117	132	76	94	94	95	92	64	72	74	85
Oak, swamp white (Indiana):																													
Green	150			96	92	98	92	94	100	74	85	68	97	106	76	85	90	99	82	92	88	100	91	85	91	90	99	93	101
Air-dry							80	103	95	61	95	103	89	92	77	80	74	94	85	59	69	90	90	72	82	66	76	56	
Oak, tanbark (California):																													
Green	115						130	119	119								147	125		169									
Air-dry							85	105	110									108											
Oak, water (Louisiana):																													
Green	111			102	80	98	112	100	111	104	85	79	100	120	80	88	98	98	111	98	106	116	114	101	100	104	101	105	135
Air-dry							86	101	108	53	142	92	95	107	81	93	62	86	150	115	81	95	85	96	90	79	102	92	101
Oak, white (Arkansas):																													
Green	132			95	109	82	80	84	77	76	81	79	84	83	78	89	68	86	56	89	92	96	87	91	99	104	108	99	100
Air-dry							66	82	80	52	66	66	67	76	55	55	46	86	47	74	98	99	106	88	94	85	88	44	108
Oak, white (Indiana):																													
Green	138			86	85	88	88	89	88	93	87	76	87	87	77	87	88	85	76	77	93	100	100	91	100	83	106	89	119
Air-dry							62	100	92	44	72	45	84	100	66	52	76	103	82	69	72	95	89	103	103	77	97	72	99
Oak, white (Richland Parish, Louisiana):																													
Green	136			96	84	90	81	80	80	74	58	41	94	82	95	69	85	84	69	106	97	108	105	88	98	92	102	89	119
Air-dry							73	91	84	58	79	58	78	90	64	79	67	82	66	41	69	93	84	79	91	51	107	27	87
Oak, white (Winn Parish, Louisiana):																													
Green	131			99	96	94	101	90	90	100	79	55	84	103	61	92	96	91	99	86	96	104	101	94	93	88	104	94	108
Air-dry							75	89	87	60	98	69	85	82	76	100	63	82	120	110	66	81	68	86	93	50	85	54	102
Oak, willow (Louisiana):																													
Green	109			120	94	101	88	84	93	81	67	55	84	102	66	85	76	78	88	100	96	104	103	100	102	116	112	117	126
Air-dry							83	79	93	67	77	85	75	90	113	77	67	78	122	119	56	69	90	57	88		128		113

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Oak, yellow (Arkansas):																													
Green	122	.....	.....	88	83	100	100	94	86	105	85	76	94	88	92	98	85	94	90	112	100	112	106	98	91	107	114	119	128
Air-dry	.....	.....	.....	.....	.....	.....	71	89	86	57	82	83	73	85	63	116	80	84	90	59	83	110	96	95	97	81	94	85	.....
Oak, yellow (Wisconsin):																													
Green	105	.....	.....	.....	.....	.....	75	87	81	66	102	95	108	74	150	88	.....	81	.....	110	86	92	90	110	105	98	92	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	83	105	92	73	102	90	88	89	87	83	82	95	88	76	108	110	105	120	112	121	123	120	119
Osage orange (Indiana):																													
Green	164	.....	.....	42	.....	.....	107	105	70	126	156	117	90	64	95	138	83	111	62	172	92	131	100	.....	.....	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Poplar, yellow (tulip tree) (Tennessee):																													
Green	35	....	....	110	116	110	104	103	129	97	94	66	115	122	122	86	102	99	144	100	102	96	94	102	116	125	166	128	180
Air-dry	....	....	....	....	....	....	129	99	127	159	108	100	158	142	202	114	123	102	171	102	88	83	92	96	100	144	149	118	164
Rhododendron, great (Tennessee):																													
Green	85	....	....	114	132	102	102	85	67	147	107	101	....	65	....	69	....	100	....	135	123	123	120	110	112	....	....	....	....
Air-dry	....	....	....	....	....	....	86	77	72	100	92	71	50	67	36	40	90	81	81	107	....	....	....	....	....	84	66	99	119
Sassafras (Tennessee):																													
Green	51	....	....	87	99	86	104	97	88	130	96	128	104	92	127	146	104	93	72	113	122	122	114	121	103	151	126	149	125
Air-dry	....	....	....	....	....	....	105	86	88	142	112	216	87	83	113	132	89	81	67	164	86	123	112	108	94	122	112	149	110
Serviceberry (Tennessee):																													
Green	156	....	....	104	107	96	95	90	102	74	92	71	87	106	62	103	80	90	81	76	88	99	99	79	86	72	81	81	79
Air-dry	....	....	....	....	....	....	101	88	88	98	90	95	98	103	85	90	108	91	61	83	79	89	83	64	84	....	....	....	....
Silverbell-tree (Tennessee):																													
Green	49	....	....	109	95	107	101	104	111	100	117	103	113	111	124	109	93	98	104	108	102	98	98	112	110	128	135	117	130
Air-dry	....	....	....	....	....	....	98	80	99	112	69	81	113	106	135	90	101	86	118	85	108	86	90	91	90	110	132	93	90
Sourwood (Tennessee):																													
Green	89	....	....	108	131	104	100	96	103	90	88	68	107	104	107	106	94	93	130	104	106	101	102	106	110	128	132	131	136
Air-dry	....	....	....	....	....	....	110	80	92	123	83	83	116	98	137	103	104	87	192	91	114	98	94	105	77	106	79	50	55
Sumac, staghorn (Wisconsin):																													
Green	61	....	....	....	....	....	79	85	72	93	123	190	....	....	....	....	....	87	....	101	112	110	110	....	....	....	....	....	....
Air-dry	....	....	....	....	....	....	131	89	90	203	80	95	....	....	....	....	129	99	85	132	110	120	100	....	....	....	....	....	....
Sycamore (Indiana):																													
Green	63	....	....	106	115	95	74	91	85	71	81	61	93	86	104	85	92	89	83	88	112	107	114	102	115	116	159	137	166
Air-dry	....	....	....	....	....	....	71	84	91	64	66	45	62	74	54	46	77	88	95	76	86	95	98	80	88	77	126	85	110
Sycamore (Tennessee):																													
Green	65	....	....	112	119	102	94	94	100	92	86	72	101	105	101	93	96	97	100	91	106	106	104	97	105	112	125	107	146
Air-dry	....	....	....	....	....	....	109	86	103	119	107	92	62	97	44	112	103	84	106	92	87	85	101	76	....	....	....	....	....
Umbrella, Fraser (Tennessee):																													
Green	45	....	....	112	115	110	100	102	117	95	118	98	112	118	119	100	104	95	115	85	118	114	121	104	103	130	132	125	135
Air-dry	....	....	....	....	....	....	126	94	107	166	125	119	125	126	142	121	123	91	144	85	112	108	104	94	105	142	144	159	174
Willow, black (Wisconsin):																													
Green	11	....	....	134	70	147	52	71	58	67	269	237	105	55	104	272	54	58	54	77	94	114	121	86	93	154	156	161	185
Air-dry	....	....	....	....	....	....	89	77	57	207	174	149	80	68	130	118	73	68	46	102	110	116	110	124	128	144	161	122	143
Willow, western black (Oregon):																													
Green	43a	....	....	120	77	134	95	95	102	102	157	154	100	110	101	144	86	86	119	92	110	128	128	105	112	110	101	99	106
Air-dry	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Witch hazel (Tennessee):																													
Green	114	....	....	116	....	....	100	92	79	114	144	142	104	79	123	85	....	88	....	77	100	106	111	86	88	....	....	....	....
Air-dry	....	....	....	....	....	....	94	82	76	102	104	....	....	....	....	....	101	74	95	101	121	128	117	....	....	....	....	....	....

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
CONIFERS.																													
Cedar, incense (California):																													
Green	26	.....	.....	.....	.....	.....	136	115	83	.....	.....	.....	.....	.....	.....	.....	159	121	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Cedar, western red (Montana):																													
Green	2	.....	.....	90	89	92	114	105	109	146	100	83	116	123	139	119	157	130	117	142	164	110	119	132	118	130	99	114	98
Air-dry	.....	.....	.....	.....	.....	.....	106	93	115	125	100	128	116	130	144	86	193	119	163	144	154	100	119	99	100	90	67	72	85
Cedar, western red (Washington):																													
Green	10	.....	.....	93	80	101	140	124	124	190	121	110	133	121	180	121	160	135	135	149	159	104	108	128	119	112	92	100	76
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Cedar, white (Wisconsin):																													
Green	1			85	75	95	115	106	87	196	156	132	105	90	161	128	97	98	90	151	110	88	88	126	115	156	128	149	121
Air-dry							120	110	90	228	130	144	95	100	128	126	107	102	93	108	114	106	117	119	123	142	145	121	128
Cypress, bald (Louisiana):																													
Green	62			91	89	78	117	105	123	135	59	71	94	106	88	81	141	127	134	115	77	67	67	95	84	72	59	61	53
Air-dry							111	115	120	135	88	144	75	85	74	88	135	138	134	78	91	84	88	76	57	50	56	41	35
Douglas fir (California):																													
Green	45a			102	118	102	126	114	133	128	85	72	113	130	110	92	127	123	182	114	101	98	101	102	95	61	53	67	62
Air-dry																													
Douglas fir (Oregon):																													
Green	67a			101	129	97	123	111	144	105	76	76	107	127	93	88	132	128	180	104	81	83	90	93	89	39	38	26	42
Air-dry																													
Douglas fir (Chehalis County, Washington):																													
Green	46a			108	111	105	122	111	133	117	81	86	107	131	97	85	127	119	167	121	95	92	97	117	102	66	69	46	58
Air-dry																													
Douglas fir (Lewis County, Washington):																													
Green	75			93	110	103	130	110	136	121	71	83	101	126	83	83	140	126	165	101	74	77	83	96	89	62	58	49	49
Air-dry																													
Douglas fir (Washington and Oregon):																													
Green	67						133	118	138									127											
Air-dry																													
Douglas fir (Wyoming):																													
Green	48			95	92	93	107	100	116	92	90	72	103	119	94	74	105	101	120	111	77	85	88	98	91	62	50		
Air-dry							87	104	105	85	83	135	90	123	76	118	120	116	108	102	104	117	121	96	80	58	42		
Fir, alpine (Colorado):																													
Green	4			110	85	137	97	102	109	110	104	87	97	105	110	67	108	97	100	154	125	100	117	107	112	121	108		
Air-dry							103	111	91	184	81	128	71	96	71	106	123	111	95	125	96	90	122	102	113	101	90		
Fir, amabilis (Oregon):																													
Green	39						130	118	138								150	115											
Air-dry																													
Fir, amabilis (Washington):																													
Green	18			140	135	168	122	110	139	130	108	106	122	143	118	121	130	110	153	108	104	94	108	105	93	93	94	76	104
Air-dry																													
Fir, balsam (Wisconsin):																													
Green	14			105	88	116	112	102	113	129	96	76	112	114	132	99	129	104	132	81	87	94	104	99	94	96	90	74	71
Air-dry																													

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
CONIFERS—contd.																													
Fir, grand (Montana):																													
Green	36	.....	.....	101	98	107	110	106	133	104	94	120	120	126	127	139	125	117	168	100	106	95	104	111	105	103	85	90	74
Air-dry	.....	.....	.....	.....	.....	.....	108	104	146	96	142	323	145	130	196	196	160	101	.....	79	113	98	142	101	97	328	66	45	52
Fir, noble (Oregon):																													
Green	16	.....	.....	137	147	153	119	111	143	117	112	135	120	128	135	111	130	112	171	111	85	76	83	105	101	76	76	63	71
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Fir, white (California):																													
Green	17	.....	.....	93	102	118	135	116	125	169	94	123	114	126	121	106	144	116	132	146	106	100	105	118	106	106	119	91	108
Air-dry	.....	.....	.....	.....	.....	.....	119	108	127	137	92	113	82	93	92	91	130	115	129	118	150	121	119	95	109	106	104	72	90

Hemlock, black (Montana):																													
Green	47	.....	.....	90	110	100	99	95	88	123	123	172	106	93	128	139	114	100	101	94	110	99	100	106	99	87	92	83	101
Air-dry	.....	.....	.....	.....	.....	.....	101	92	84	140	105	77	117	104	146	154	105	103	97	135	139	97	102	90	95	66	64	49	88
Hemlock eastern (Tennessee):																													
Green	52	.....	.....	94	94	108	137	118	123	156	88	114	114	113	121	92	142	129	124	133	102	98	96	121	98	76	67	51	58
Air-dry	.....	.....	.....	.....	.....	.....	123	101	110	151	78	116	125	114	154	149	163	115	145	149	95	83	80	85	86	30	48	.....	29
Hemlock, eastern (Wisconsin):																													
Green	15	.....	.....	92	71	87	121	114	103	166	125	110	101	100	123	102	120	117	109	164	140	121	114	128	122	126	79	119	118
Air-dry	.....	.....	.....	.....	.....	.....	101	97	97	142	98	156	84	85	110	92	115	115	105	121	146	103	86	118	118	88	67	83	.....
Hemlock, western (Washington):																													
Green	50	.....	.....	.....	.....	.....	126	116	135	.....	.....	.....	.....	.....	.....	.....	147	117	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	93	110	126	.....	.....	.....	.....	.....	.....	.....	.....	102	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Larch, western (Montana):																													
Green	84	.....	.....	93	89	96	112	98	109	113	66	64	93	108	96	67	115	113	107	90	61	66	67	91	83	53	52	40	45
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Larch, western (Washington):																													
Green	64	.....	.....	.....	.....	.....	110	104	114	.....	.....	.....	.....	.....	.....	.....	.....	117	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, Cuban (Florida):																													
Green	127	.....	.....	76	106	76	106	92	110	90	54	72	92	105	74	76	115	111	108	71	53	65	64	86	71	46	44	40	40
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, jack (Wisconsin):																													
Green	43	.....	.....	90	90	97	92	93	92	98	87	128	103	90	108	132	106	95	93	101	81	85	90	101	91	98	82	85	94
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, Jeffrey (California):																													
Green	33	.....	.....	93	124	107	103	90	102	117	76	110	103	100	123	107	104	93	106	113	77	90	98	97	96	87	94	83	90
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, loblolly (Florida):																													
Green	88	.....	.....	87	114	88	105	95	112	96	72	85	93	105	79	88	100	106	105	89	50	62	66	92	75	62	58	52	50
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, lodgepole (Colorado):																													
Green	31	.....	.....	110	119	113	106	99	112	117	91	61	97	100	109	79	118	99	115	117	69	84	86	96	98	87	76	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	129	109	113	188	121	105	69	88	66	86	143	108	101	130	86	95	112	95	80	98	72	.....	.....
Pine, lodgepole (Gallatin County, Montana):																													
Green	35a	.....	.....	115	130	108	100	102	122	93	85	112	108	116	117	125	98	104	135	95	74	86	93	99	90	81	72	69	64
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content.	Shrinkage from green to oven-dry condition.			Static bending.						Impact bending, 50-pound hammer.				Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness: load required to embed a 0.444-inch ball one-half its diameter.			Shear.		Cleavage.		Tension.	
				In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work to elastic limit.	Work to maximum load.	Total work.	Fiber stress at elastic limit.	Modulus of elasticity.	Work to elastic limit.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Maximum crushing strength.	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.	Surface of failure radial.	Surface of failure tangential.
			Per cent.	Per cent of dimensions when green.			Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Inch lbs. per cu. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Inch lbs. per cu. in.	Inches.	Lbs. per sq. in.	Lbs. per sq. in.	1,000s of lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.	Lbs.	Lbs.	Lbs. per sq. in.	Lbs. per sq. in.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
CONIFERS—contd.																													
Pine, lodgepole (Granite County, Montana).																													
Green	41a	.....	.....	105	133	98	94	95	105	90	85	63	100	112	102	101	98	96	140	79	74	85	85	90	85	79	67	68	68
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, lodgepole (Jefferson County, Montana):																													
Green	40a	.....	.....	105	135	105	94	96	112	85	88	86	97	112	96	95	108	103	165	77	74	76	90	90	80	79	66	72	65
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....

Pine, lodgepole (Wyoming):																													
Green	34	.....	.....	99	102	94	89	93	101	87	85	85	94	100	101	83	98	94	94	106	71	81	81	105	98	166	114	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	110	113	100	154	86	74	95	100	106	110	128	114	99	126	89	98	97	86	67	86	52	.....	.....
Pine, longleaf (Florida):																													
Green	123	.....	.....	74	93	71	104	92	112	87	54	72	91	109	68	67	113	110	111	73	50	61	64	89	73	46	38	37	36
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, longleaf (Lake Charles, Louisiana):																													
Green	113	.....	.....	82	102	83	115	99	117	96	60	74	91	111	68	69	127	118	123	81	53	67	69	90	81	48	44	44	44
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, longleaf (Tangipahoa Parish, Louisiana):																													
Green	96	.....	.....	88	119	85	109	104	126	90	69	104	90	109	71	88	112	117	125	69	67	66	69	96	80	59	50	44	55
Air-dry	.....	.....	.....	.....	.....	.....	105	107	117	94	95	96	94	110	85	96	111	121	109	92	66	73	80	113	89	77	45	61	52
Pine, longleaf (Mississippi):																													
Green	95	.....	.....	74	96	85	103	94	107	100	61	76	91	103	77	76	120	111	112	76	55	69	72	94	83	53	45	45	44
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, Norway (Wisconsin):																													
Green	57	.....	.....	92	110	96	99	95	123	83	68	128	86	107	72	100	102	101	131	75	58	65	64	93	78	72	60	46	44
Air-dry	.....	.....	.....	.....	.....	.....	119	117	123	128	106	110	106	115	106	96	128	126	129	77	76	81	90	98	76	81	67	77	95
Pine, pitch (Tennessee):																													
Green	71	.....	.....	87	107	93	86	88	91	88	83	114	94	87	94	86	80	94	88	90	73	85	88	97	88	80	73	80	61
Air-dry	.....	.....	.....	.....	.....	.....	86	85	90	93	72	65	102	96	138	83	93	91	103	169	81	94	88	92	88	86	72	64	100
Pine, pond (Florida):																													
Green	86	.....	.....	77	107	83	102	94	101	102	68	85	93	100	83	92	105	105	97	90	58	72	72	96	79	64	58	51	53
Air-dry	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pine, shortleaf (Arkansas):																													
Green	77	.....	.....	.....	.....	.....	107	105	117	95	.....	.....	.....	.....	.....	.....	133	108	.....	73	.....	.....	.....	78	65	.....	.....	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	.....	106	115	81	.....	.....	.....	.....	.....	.....	.....	103	.....	77	.....	.....	.....	80	70	.....	.....	.....	.....
Pine, sugar (California):																													
Green	22	.....	.....	85	85	92	113	100	106	140	88	92	101	100	119	92	124	105	100	121	90	94	105	106	99	112	110	94	100
Air-dry	.....	.....	.....	.....	.....	.....	112	106	106	139	87	84	100	101	125	112	150	112	119	107	110	108	102	125	90	119	119	106	121
Pine, Table Mountain (Tennessee):																													
Green	82	.....	.....	79	72	81	107	99	104	110	79	102	102	104	100	83	106	104	99	88	66	77	77	96	85	72	62	67	55
Air-dry	.....	.....	.....	.....	.....	.....	105	90	100	114	76	71	108	110	121	106	91	102	125	112	62	76	68	91	80	71	64	.....	.....
Pine, western white (Montana):																													
Green	42	.....	.....	104	109	111	106	96	132	94	74	117	100	118	96	104	131	113	141	88	74	81	86	94	87	90	84	68	76
Air-dry	.....	.....	.....	.....	.....	.....	126	106	136	144	149	146	119	138	121	139	150	114	153	110	77	96	88	.....	54	55	53	.....	34

TABLE 1.—*Equations and variations—specific gravity, shrinkage, and strength relations based on tests of small clear pieces, green and air-dry*—Con.

III.—ACTUAL VALUE OF EACH PROPERTY FOR EACH "SPECIES-LOCALITY" AS DETERMINED BY TESTS—EXPRESSED IN PERCENTAGE OF EQUATION VALUE—Continued.

Species and locality.	Reference number.	Specific gravity, oven-dry, based on volume at time of test.	Moisture content. Per cent.	Shrinkage from green to oven-dry condition. In volume. Per cent of dimensions when green.	Shrinkage: Radial.	Shrinkage: Tangential.	Static bending. Fiber stress at elastic limit. Lbs. per sq. in.	Static bending. Modulus of rupture. Lbs. per sq. in.	Static bending. Modulus of elasticity. 1,000s of lbs. per sq. in.	Static bending. Work to elastic limit. Inch lbs. per cu. in.	Static bending. Work to maximum load. Inch lbs. per cu. in.	Static bending. Total work. Inch lbs. per cu. in.	Impact bending, 59-pound hammer. Fiber stress at elastic limit. Lbs. per sq. in.	Impact bending. Modulus of elasticity. 1,000s of lbs. per sq. in.	Impact bending. Work to elastic limit. Inch lbs. per cu. in.	Impact bending. Height of drop causing complete failure. Inches.	Compression parallel to grain. Fiber stress at elastic limit. Lbs. per sq. in.	Compression parallel to grain. Maximum crushing strength. Lbs. per sq. in.	Compression parallel to grain. Modulus of elasticity. 1,000s of lbs. per sq. in.	Compression perpendicular to grain, fiber stress at elastic limit. Lbs. per sq. in.	Hardness: load required to embed a 0.444-inch ball one-half its diameter. End surface. Lbs.	Hardness: Radial surface. Lbs.	Hardness: Tangential surface. Lbs.	Shear. Surface of failure radial. Lbs. per sq. in.	Shear. Surface of failure tangential. Lbs. per sq. in.	Cleavage. Surface of failure radial. Lbs.	Cleavage. Surface of failure tangential. Lbs.	Tension. Surface of failure radial. Lbs. per sq. in.	Tension. Surface of failure tangential. Lbs. per sq. in.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
CONIFERS—contd.																													
Pine, western yellow (Arizona):																													
Green	19	.....	.....	91	122	107	90	90	95	99	86	98	97	94	116	100	103	91	103	90	76	85	88	103	100	112	114	121	114
Air-dry	.....	.....	.....	.....	.....	.....	101	96	89	135	69	101	84	100	97	72	110	110	92	114	109	112	106	142	128	150	166	142	141
Pine, western (California):																													
Green	37	.....	.....	108	120	114	99	90	113	95	66	102	100	98	117	105	105	93	118	100	73	79	85	98	93	100	101	83	77
Air-dry	.....	.....	.....	.....	.....	.....	126	106	115	161	117	141	96	102	109	103	147	113	110	117	81	100	98	100	108	112	112	92	141
Pine, western (Colorado):																													
Green	41	.....	.....	90	102	87	100	92	104	104	86	73	91	100	90	88	107	97	105	119	71	83	85	92	88	84	74	.....	.....
Air-dry	.....	.....	.....	.....	.....	.....	95	111	99	110	99	110	75	97	73	109	125	110	87	102	92	94	87	98	93	121	103	.....	.....

Pine, western (Montana):																													
Green	32	....	....	87	99	94	98	92	93	121	88	110	92	93	106	93	105	93	100	90	72	83	88	95	89	105	96	94	101
Air-dry	....	....	....	....	....	....	113	90	109	142	90	125	109	111	139	100	129	103	127	111	85	96	101	97	86	94	93	110	86
Pine, white (Wisconsin):																													
Green	25	....	....	77	64	96	114	100	116	128	101	102	91	101	95	88	124	108	128	108	77	86	86	92	84	89	87	81	85
Air-dry	....	....	....	....	....	....	122	108	122	156	110	172	85	106	85	104	147	115	117	131	109	115	108	92	101	128	97	92	97
Redwood (Albion, California):																													
Green	28	....	....	....	....	....	107	143	120	....	....	....	....	....	....	....	....	165	....	202	....	....	....	....	....	....	....	....	....
Air-dry	....	....	....	....	....	....	86	101	96	....	....	....	....	....	....	....	143	114	92	118	....	....	....	79	73	....	....	....	....
Redwood (Korbel, California):																													
Green	13	....	....	....	....	....	171	140	122	....	....	....	....	....	....	....	....	166	....	213	....	....	....	....	....	....	....	....	....
Air-dry	....	....	....	....	....	....	96	113	114	....	....	....	....	....	....	....	103	124	115	98	....	....	....	86	56	....	....	....	....
Spruce, Engelmann (Grand County, Colorado):																													
Green	8	....	....	117	121	125	107	99	105	130	104	64	106	108	126	85	113	97	110	137	100	106	115	103	98	88	94	....	....
Air-dry	....	....	....	....	....	....	97	117	100	121	107	114	92	103	110	116	122	116	101	132	94	83	90	109	104	121	98	....	....
Spruce, Engelmann (San Miguel County, Colorado):																													
Green	3	....	....	123	107	121	94	93	106	112	128	86	89	91	104	96	106	87	113	142	100	105	110	91	93	102	98	....	....
Air-dry	....	....	....	....	....	....	86	138	105	92	139	182	71	85	74	85	95	112	97	108	92	104	110	75	72	110	98	....	....
Spruce, red (New Hampshire):	44																												
Green		....	....	....	....	....	108	102	117	116	92	....	....	....	....	....	....	107	....	96	83	83	87	103	99	77	85	....	....
Air-dry	....	....	....	....	....	....	107	122	125	106	128	149	96	109	100	144	....	121	....	77	94	95	103	103	104	85	81	....	....
Spruce, red (Tennessee):																													
Green	29	....	....	115	109	126	109	102	129	104	102	100	105	111	112	94	122	102	127	119	114	96	103	110	106	85	91	60	90
Air-dry	....	....	....	....	....	....	128	104	122	159	128	118	118	120	137	165	153	110	135	110	112	109	114	89	97	83	100	125	98
Spruce, white (New Hampshire):																													
Green	7	....	....	....	....	....	120	110	113	146	139	66	....	....	....	....	....	89	....	100	106	94	100	106	93	100	88	....	....
Air-dry	....	....	....	....	....	....	103	124	121	108	144	196	98	115	105	139	129	117	133	77	91	98	102	118	110	121	120	123	111
Spruce, white (Wisconsin):																													
Green	38	....	....	144	103	115	109	98	104	136	87	109	97	106	94	101	114	98	94	99	66	73	71	101	91	83	76	67	66
Air-dry	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Tamarack (Wisconsin):																													
Green	81	....	....	101	79	89	100	96	101	110	71	110	80	100	74	85	108	103	114	83	56	61	58	90	79	62	52	52	50
Air-dry	....	....	....	....	....	....	97	97	106	94	64	90	86	92	88	81	103	110	113	85	60	72	69	93	85	81	67	79	63
Yew, western (Washington):																													
Green	134	....	....	57	70	53	120	102	68	190	123	126	86	91	128	82	94	112	58	112	115	119	110	135	124	69	60	64	67
Air-dry	....	....	....	....	....	....	94	96.	79	110	109	67	47	68	53	....	73	102	64	240	125	154	108	120	122	41	42	....	45